

# SEDAR 14

## Stock Assessment Report 1

### Caribbean Yellowfin Grouper

#### SECTION II. Data Workshop

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## SEDAR 14

## Yellowfin Grouper

## Data Workshop Report

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# 1. Introduction

## 1.1. Workshop Time and Place

The SEDAR 14 data workshop was held March 12 - 16, 2007, in St. Thomas, USVI.

## 1.2. Terms of Reference

1. Characterize stock structure and develop a unit stock definition. Provide a map of stock distribution.
2. Tabulate available life history information (e.g., age, growth, natural mortality, reproductive characteristics); provide appropriate models to describe growth, maturation, and fecundity by age, sex, or length as applicable. Evaluate the adequacy of available life-history information for conducting stock assessments and recommend life history information for use in population modeling. Provide distribution maps.
3. Provide measures of population abundance that are appropriate for stock assessment. Document all programs used to develop indices, addressing program objectives, methods, coverage, sampling intensity, and other relevant characteristics. Provide maps of survey effort. Consider relevant fishery dependent and independent data sources; develop values by appropriate strata (e.g., age, size, area, and fishery); provide measures of precision. Evaluate the degree to which available indices adequately represent fishery and population conditions. Recommend which data sources should be considered in assessment modeling.
4. Characterize commercial and recreational catch, including both landings and discard removals, in weight and number. Evaluate the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector. Provide length and age distributions if feasible. Provide maps of fishery effort and harvest.
5. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity and coverage where possible.
6. Prepare complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report).

## 1.3. List of Participants

NAME	Appointed by/Affiliation
<u>Appointed Panelists</u>	
Josh Bennett .....	NOAA Fisheries/SEFSC
Nancie Cummings .....	NOAA Fisheries/SEFSC
Guillermo Diaz.....	NOAA Fisheries/SEFSC
Rene Esteves .....	CFMC/UPR
Ron Hill.....	NOAA Fisheries/SEFSC
Chris Jeffrey .....	NOAA Fisheries/NOS
Joe Kimmel .....	NOAA Fisheries/SERO
Hector López-Pelet .....	DRNA/PR/LIP
Jimmy Magner .....	CFMC AP
Andy Maldonado .....	CFMC AP

Kevin McCarthy.....NOAA Fisheries/SEFSC  
 Luis Rivera.....DRNA/PR/LIP  
 Aurea Rodriguez.....CFMC/UPR  
 Michelle Scharer.....CFMC/UPR  
 William Tobias.....CFMC SSC  
 Wes Toller.....CFMC AP  
 Steve Turner.....NOAA Fisheries/SEFSC

Council Representative

David Olsen.....CFMC SSC

STAFF

John Carmichael.....SEDAR  
 Tyree Davis.....NOAA Fisheries/SEFSC  
 Graciela Garcia-Moliner.....CFMC  
 Rachael Lindsay.....SEDAR

1.4. Supporting Documents

Working Papers Prepared for the data workshop

Document #	Title	Authors
<b>Documents Reviewed at the Data Workshop</b>		
SEDAR14-RD01	Expansion of the SEAMAP_C fishery independent sampling program. Overview Document.	Cummings, N., R. Trumble, R. Wakeford
SEDAR14-RD02 MRAG Americas 2006	A pilot program to assess methods of collection bycatch, discard, and biological data in the commercial fisheries of St. Thomas, US Caribbean. CRP Report, SERO Grant # NA05NMF4540042	Trumble, R. J., D. Olsen, N. Cummings.
SEDAR14-RD03 MRAG Americas 2006	A pilot program to assess methods of collection bycatch, discard, and biological data in the commercial fisheries of the US Caribbean. CRP Report, SERO Grant # NA04NMF4540214	Trumble, R. J., et al.
SEDAR14-RD04 MRAG London 2005	Fisheries management decisions with limited resources and data: PARFish Synthesis Document.	Walmsley, S. F., P.A. H. Medley, C.A. Howard
SEDAR14-RD05 PR DNER 2005	Bycatch study of Puerto Rico's marine commercial fisheries. Grant NA04NMF433071	Matos, D.
SEDAR14-RD06 MS Thesis UPR 2005	Dispersal of reef fish larvae from known spawning sites in La Parguera	Esteves Amador, R. F.
SEDAR14-RD07 MRAG Rpt. 2003	Integrated fisheries management using Bayesian multi-criterion decision making (R7947)	Medley, P. A.
SEDAR14-RD08 MARFIN	Bycatch Study of Puerto Rico's Marine Commercial Fisheries.	Matos, D.

NA04NMF433071 2005		
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### Reference Documents Available at the Data Workshop

SEDAR14-RD01	Expansion of the SEAMAP_C fishery independent sampling program. Overview Document.	Cummings, N., R. Trumble, R. Wakeford
SEDAR14-RD02 MRAG Americas 2006	A pilot program to assess methods of collection bycatch, discard, and biological data in the commercial fisheries of St. Thomas, US Caribbean. CRP Report, SERO Grant # NA05NMF4540042	Trumble, R. J., D. Olsen, N. Cummings.
SEDAR14-RD03 MRAG Americas 2006	A pilot program to assess methods of collection bycatch, discard, and biological data in the commercial fisheries of the US Caribbean. CRP Report, SERO Grant # NA04NMF4540214	Trumble, R. J., et al.
SEDAR14-RD04 MRAG London 2005	Fisheries management decisions with limited resources and data: PARFish Synthesis Document.	Walmsley, S. F., P.A. H. Medley, C.A. Howard
SEDAR14-RD05 PR DNER 2005	Bycatch study of Puerto Rico's marine commercial fisheries. Grant NA04NMF433071	Matos, D.
SEDAR14-RD06 MS Thesis UPR 2005	Dispersal of reef fish larvae from known spawning sites in La Parguera	Esteves Amador, R. F.
SEDAR14-RD07 MRAG Rpt. 2003	Integrated fisheries management using Bayesian multi-criterion decision making (R7947)	Medley, P. A.
SEDAR14-RD08 MARFIN NA04NMF433071 2005	Bycatch Study of Puerto Rico's Marine Commercial Fisheries.	Matos, D.
SEDAR14 RD09 SERO CRP NA05NMF4540042 2006	A pilot program to assess methods of collecting bycatch, discard, and biological data in the commercial fisheries of St. Thomas, U.S. Caribbean	Trumble, R. J., D. Olsen, and N. Cummings.
SEDAR14-RD10 SERO CRP NA04NMF4540214 2006	A pilot program to assess methods of collecting bycatch, discard, and biological data in the commercial fisheries of the US Caribbean	Trumble, R. J. et al.

## 2. Life History Group Report

### 2.1. Introduction

Interest in the status of the yellowfin grouper, *Mycteroperca venenosa*, populations off Puerto Rico and the U.S. Virgin Islands prompted the need to review and assemble the available biological and fishery information for this species. Historically this species has been an important component of commercial fisheries of Bermuda and one of the most abundant groupers in the Caribbean (Heemstra and Randall, 1993). Recent data on the landings and stock status of this species is lacking, except for Bermuda and the US Caribbean. Information on the life history and ecology is an integral component of stock assessment evaluations. This report reviews and synthesizes biological information from published and un-published sources with



emphasis on yellowfin grouper populations in the U.S. Caribbean for use in stock assessment evaluations. This review made extensive use of the material reference in Froese and Pauly (2007).

## 2.2. Stock Definition and Description

The US Caribbean yellowfin grouper management stock is defined as those individuals from the population found within territorial and U.S. EEZ waters of Puerto Rico and the US Virgin Islands. Yellowfin grouper are part of the reef fish management unit (FMU Unit 4) in the Caribbean Fishery Management Council's Reef Fish Fishery Management Plan. Presently the US Caribbean population of yellowfin grouper is managed assuming one stock.

Little information exists to document movements in the yellowfin grouper. Limited tagging data from a 1962 study at Lameshur Bay on the south shore of St. John (U.S. Virgin Islands) suggests that movements of adult yellowfin grouper are limited to only a few miles (Randall 1962). In that study fish at large from one month to 513 days (1.4 years) generally moved four miles or less (Randall 1962). However, from recent tagging operations by recreational fishers off the Florida Keys, a fish tagged off the Marquesas Keys (Gulf of Mexico) in November 2004 was reported caught 289 days later in September, 2005 200 miles away, off the Berry Islands in the Bahamas (Gregory, 2006).

It was also noted that there exists some possibility exists of recruitment into areas of Puerto Rico, the British Virgin Islands and the US Virgin Islands (St. Thomas, St. John) from areas to the east (*i.e.*, Saba Bank, Anguilla, St. Marten (Netherlands Antilles). However, Roberts (1997) suggested that the probability is low, for marine species with a short larval duration period such as many of the snappers and groupers. Information on the pelagic larval duration (PLD) is not known for the yellowfin grouper, however information on the PLD for species similar to this species indicates a PLD's of 31-45 days for *M. bonaci* off the South Carolina, 33-66 days for *M. microlepis* off South Carolina (Keener et al., 1988 cited in Lindeman et al. 2000), and 37-45 days for *E. striatus* off the Bahamas (Colin et al., 1997 cited in Lindeman et al. 2000).

Based on the short length of the planktonic phase, information on prevailing surface currents, the low probability of larval input from adjacent regions, and indication of restricted movement of adults the history sub-group suggested a two stock hypothesis for the yellowfin grouper populations in the US Caribbean. The two stocks are: one stock on the Puerto Rico geological platform (*i.e.*, Puerto Rico, St. Thomas/St. John (US Virgin Islands) and the British Virgin Islands (BVI) and, one stock around St. Croix, US Virgin Islands.

## 2.3. Species Description and Taxonomy

The yellowfin grouper species is a member of the genus *Mycteroperca*, family Serranidae (*i.e.*, sea bass family) and commonly occurs in tropical, subtropical, and temperate seas (Figure 1). Many of the members of the Serranidae family are notably quite colorful, in particular those of the genera *Mycteroperca* and *Epinephelus*. Most members of the Serranidae also have the characteristic ability to change colors in response to background. Smith (1961) wrote that "perhaps the best taxonomic characters of the groupers are features of coloration- shade and hue as well as pattern". Sutherland et al. (1986) described members of these two families as: "being cosmopolitan in distribution, representing an important food resource, solitary, occurring over a

wide depth distribution, inhabiting shallow inshore grass beds as juveniles out to the continental shelf break (adults), preferring hard bottom and offshore reefs that offer hiding niches.

Common names of the yellowfin grouper include salmon grouper (St. Croix), grammanik grouper (St. Thomas and St. John), Guajil and mero pinto (Puerto Rico). In Bermuda the yellowfin grouper is known as the red rockfish Princess rockfish, off Cuba as Bonaci cardinal and Arigua, and off Venezuela, is known as Bonaci de Piedra and Cuna Cucaracha (Heemstra and Randall, 1993)

The yellowfin grouper is variably colored, sometimes olive-green with rows of rounded, irregular, dark blotches on its back (Figure 2). The belly is often salmon pink, and the mouth yellow inside and along the corners. The outer 1/3 of the pectoral fin is a brilliant yellow (<http://www.boldwater.com/groupergallery.shtml>). Specimens taken from depths of 35 m or more often have distinct red body coloration and even darker red blotches over the body (Figure 3). Two dominant color phases or morphs were reported for the yellowfin grouper by Smith (1971), one the deep-water reddish form and another, more brownish green observed in shallow water inhabitants (Thompson and Munro, 1974) noted that juvenile yellowfin grouper were a deeper red than adults captured at comparable depths off Jamaica. These authors hypothesized that the transition from red to more dark brownish color was either a developmental trait or possibly suggests a movement of juveniles from deeper to shallow waters. Bohlke and Chaplin (1968) reported that the yellowfin grouper can become pale over bare sand, or almost black when at rest under coral heads.

Visual similarities between the yellowfin grouper and the black grouper (*Mycteroperca bonaci*) and gag grouper (*M. microlepis*) have been noted, particularly in the rows of rectangular spots and blotches and the general dark coloration often observed which, tend to be larger and more defined in the black grouper. Also, the caudal fin of the black grouper tends to be straighter than that of the yellowfin grouper. Clear, distinguishing features include the wide, yellow margin on the pectoral fins in the yellowfin grouper, usually a narrow, orange outer margin observed on the black grouper pectoral fins.

The name ‘*venenosa*’ is said to be derived from the characteristic toxicity associated found in large specimens in regions where ciguatera occurs. Brownell and Rainey (1971) commented on ciguatera in yellowfin grouper from the U.S. Virgin Islands, but noted that owing to its desirability as a food fish, large specimens taken from areas considered safe were readily sold and consumed. Many members of the Serranidae family are frequently used in the aquarium trade due to the large size and colorful forms ([http://zipcodezoo.com/Animals/M/Mycteroperca\\_venenosa.asp](http://zipcodezoo.com/Animals/M/Mycteroperca_venenosa.asp)).

## 2.4. Distribution

The yellowfin grouper occurs in the western Atlantic: Bermuda, Florida, around the Gulf of Mexico to Ilha dos Buzios, Brazil and central and South American coasts to the Guianas (Cervigon, 1966 cited in Brownell and Rainey, 1971; Smith 1977 cited in Fishbase, 2007, see Figure 4 for distribution map). Although the distribution of the yellowfin grouper is for the most part continuous along the east coast of Central America within the Caribbean and along the east coast of South America south to Sao Paulo, Brazil, the extent of species occurrence as regards

bathymetric range and abundance is not well documented. Some information exists to suggest that historically population concentrations were large throughout the distribution (Heemstra and Randall 1993).

## 2.5. Habitat Utilization

The yellowfin grouper is associated most often with irregular rock or coral bottom (Bullis and Thompson, 1965; e.g., Figures 3, 5). Juveniles occur in shallow turtle grass beds (Heemstra and Randall, 1993). Some investigators describe the species as a solitary carnivore, adults known to lurk in wrecks, reef shadows, or ledges and occasionally over mud bottoms. Smith (1971) described the most species of groupers as being “*secretive and occupying crevices, ledges, and caves on reefs and wrecks*”.

Brownell and Rainey (1971) reported this species from trap catches off the Virgin Island occurring in depths from ten feet in shallow reef areas to upwards of 38 m at the shelf edge, and the mean depth of occurrence in the Virgin Islands was about 33 m. These investigators noted that yellowfin grouper was the second most abundant grouper in the Leeward Islands and throughout the Caribbean.

Data from visual surveys off Mona Island (Puerto Rico) revealed early stage juveniles (<23 cm FL) of *M. venenosa* occurring in high vertical relief habitat such as linear reef at the bank/shelf escarpment zone (Schärer, Pers. Com.). Scharer reported that yellowfin grouper were not observed in backreef, lagoon nor forereef zones off Mona Island (Puerto Rico). Juveniles (23-45 cm FL) occurred in colonized bedrock and spur and groove habitats of high vertical relief on the bank/shelf zone as well as the bank/shelf escarpment zone. Adults were observed in colonized pavement, colonized pavement with sand channels and in spur and groove habitat on the bank/shelf zone as well as the bank/shelf escarpment zone (M. Schärer, pers. com.).

Nelson et al. (1982) reported yellowfin grouper bottom longline catches of about 0.4 kg per 100 hooks at depths of 100-198 m around Puerto Rico (west, northwest and north slope) and the U.S. Virgin Islands (north coast) from deep reef surveys conducted between 1967 and 1982. Later reports from the mid 1980's of bottom and bottom longline and trap surveys off Puerto Rico and the U.S. Virgin Islands, however indicated that yellowfin grouper were not present in longline (bottom or off bottom) catches and only occurred infrequently in traps at depths of 110-120 m (Russell 1984, Russell, 1982). During these surveys deep water snappers (silk, queen, wenchman), Epinephelid spp. groupers (snowy, misty, yellowedge), and sharks (slope, Cuban, and smooth dogfish) dominated the catches. Nelson et al. (1982) addressed the difficulties associated with using bottom longlines to sample reef fish in areas of dense coral and sponge habitat. Also, quantifying the occurrence or abundance of reef species known to be more cryptic or secretive such as the yellowfin grouper using traps, longlines (bottom, off bottom, or visual census counts (point, transect) is not without difficulties. In results of trap surveys conducted between 1979 -1980 off Puerto Rico (Mayaguez, Ponce and San Juan), Collazo (1983) reported that catches were dominated by snappers; yellowfin grouper were not reported by Collazo. However, Sylvester and Dammann (1974) noted the occurrence of yellowfin grouper in deepwater fishery surveys, conducted off the Virgin Islands between 1970 and 1972 at depths of 100-300 m using electric reels, traps, and bottom longlines, but as with earlier investigators reported that catches were dominated by silk and blackfin snappers. The absence of yellowfin

grouper from surveys using only trap gear could suggest the complexity in selecting the appropriate research tool to monitor species such as the yellowfin grouper.

Froese, R. and D. Pauly (2007) reported the depth range for this species as 2-137 m (FishBase 2007). Roe (1976) reviewed 24 years of exploratory fishing and resource assessment activities in the Gulf of Mexico and Caribbean Sea and reported the depth range as 9-284 m, and noted depths were widely variable between regions. Roe's tabled data though indicates a single observation at 284, exclusion of this point gives a range of 9 to 95 m for these early surveys. Some records reported this species as not frequently observed in the Gulf of Mexico, however Roe (1976) reported the highest catches in the survey data he reviewed occurred off Texas and on Campeche Bank (Mexico). Roe's data included surveys using trawls (shrimp, fish), handlines, traps, gillnets, and bottom setlines and the sizes of fish captured ranged from 0.5 lbs to 11.5 lbs (1.98 kg).

## 2.6. Diet and Parasitism

Randall (1967) reported information on gut contents for yellowfin grouper collected off the US Virgin Islands and Puerto Rico. Sierra et al. (2001) described feeding for Cuban yellowfin grouper. Juveniles and adults feed predominantly on fish as do other members of this genus, although sometimes, invertebrates are also consumed (e.g., squid, shrimp).

Groupers are considered to be opportunistic, generalized, top-level carnivores. Smith (1971) suggested that most groupers compete with other large and small carnivores in the same area and, particularly with other groupers and although predation occurs mainly on the younger stages, it does occur on adults (Parrish, 1985). It is worth noting that in general, the body form of the genus *Mycteroperca* is more terete (cylindrical and tapering) than that of either the *Epinephelus* or *Cephalopholis*, and the *Mycteroperca* tend to forage higher above the bottom and appear to be stronger, more agile swimmers (Randall 1967 cited in Parrish 1987). Several studies noted the narrow range of preferred diet (for fish) as well as the tendency for members of this family to forage long distances, and further noted that in general, *Mycteroperca spp* habitat may be more dependent on shelter rather than on prey distribution. Parrish (1987) noted some of the interesting ecological concerns regarding shifts in prey abundance and availability and resulting impacts on predator abundance. He noted that for the most part the diet of the groupers (and many snappers) was sufficiently broad to allow shifts in feeding between prey groups, however he also pointed out that many of the preferred prey taken by the groupers (and snappers) required hunting, and most importantly that the distribution (and abundance) of these groups are not uniformly or densely distributed. Reductions in predator abundance resulting from intensive fishing could potentially have significant impact on population levels of these prey groups (Goeden 1982 cited in Parrish 1987).

Parasitic isopods have been observed clinging to the nostrils of yellowfin grouper (Thompson and Munro, 1974). Larval tapeworms are known to become encysted in the viscera of this species as well. The ovaries of the yellowfin grouper have been observed to be infected with a reddish-brown nematode (Thompson and Munro, 1974); the latter could possibly significantly impact the egg production capability.

## 2.7. Longevity and Growth

The yellowfin grouper does not normally reach a similar maximum size as other members of the genus *Mycteroperca* (e.g., Black, scamp, gag, tiger). Yellowfin grouper attain sizes up to about 20 pounds (8 kg) and a total length of about 40 inches (100 cm TL-males). However the maximum published weight for yellowfin grouper is 18.5 kg (Froese and Pauly, 2007). Lmax (maximum size) was reported to be 86 cm for Puerto Rico (Appledorn et al., 1987) and at least 3 feet (91 cm) for the Virgin Islands (Randall, 1968). The largest of four specimens taken in the U.S. Virgin Islands experimental trap fishing studies weighed 20 pounds (9.1 kg) by Brownell and Rainey (1971). Recently off Puerto Rico, a World Underwater Spearfishing Record was recorded for a 31 lb (14 kg.) yellowfin grouper speared off the north coast in 2006 (Figure 6) and a 40 lb yellowfin grouper was recently caught by hook and line off the Florida east coast (Figure 7). Manooch (1987) provided a brief review of the growth literature for yellowfin grouper.

Munro and Williams (1985) reported growth rate (K) and asymptotic size (L-infinity) information for fish from St. John to be 0.086 and 89.5 cm TL. For fish collected off Jamaica values of 0.10 - 0.17 (range) and 86.0 cm TL were reported for K and L-infinity (n=198, Thompson and Munro, 1974). Thompson and Munro (1974) also examined otoliths for use in age and growth studies for a variety of groupers from the *Epinephelus* and *Mycteroperca* genera. These authors reported that those of the *Mycteroperca* were thinner and clear more easily in the fixing process than those of the *Epinephelus* spp.. Also, these authors reported that of all the *Mycteroperca* spp. examined only *M. venenosa* were readable. Thompson and Munro (1974) estimated from the otoliths of 27 individuals “that about 4 years were required for fishes to reach a total length of 46 to 57 cm (average 51 cm TL or 12.8 cm per year up to age 4) and at age 10, a size of about 70 cm (about 3 cm per year between age 4 and 10) would be achieved. If asymptotic size were 86 cm TL then the growth rate parameter K is 0.1.

Average monthly growth increment of 87 yellowfin grouper tagged off St. John (U.S. Virgin Island) was 5.9 mm FL per month (~7 cm/year) for fish at large from 277 to 525 days (Randall 1962). The range in size of the 87 tagged yellowfin grouper was 295-305 cm FL about 35% of the maximum observed size of fish off Puerto Rico, 86 cm.

Commercial fishery catch biostatistical samples from the U.S Virgin Islands and Puerto Rico were examined to determine historical maximum sizes in the fishery. Maximum reported length for *M. venenosa* in Puerto Rico ranged from 35 to 87 cm FL maximum weight from 7.2 and 10.7 kg. In the US Virgin Islands, the maximum length for *M. venenosa* in Puerto Rico ranged from 31.5 to 83.5 cm FL and maximum weight from 5.0 and 10 kg. Bardach et al. (1958, cited by Smith 1960) reported maximum sizes of 79 cm SL for yellowfin grouper from commercial catches in Bermuda.

Published weight length relations and length conversion formulae are presented in Tables 1 and 2 as reported by Froese and Pauly (2007).

## 2.8. Maturation, Reproduction, and Fecundity

The yellowfin grouper is believed by many to be a protogynous hermaphrodite, changing from female to male in the latter part of life. However, Tupper (1999) pointed out that only the

red hind and coney had been histologically demonstrated to be protogynous and further noted that neither Nassau grouper nor yellowfin grouper has been definitively shown to be protogynous, although both are known to aggregate (Shapiro 1987). As with the tiger grouper, *M. tigris*, and black grouper, *M. bonaci* gametogenesis is classified as “Type A”, discontinuous asynchronous, with intermittent spawning (see Garcia-Cagide et al. 2001). Different batches of oocytes mature asynchronously so ovaries carry different sizes and stages of vitellogenic oocytes (Garcia-Cagide et al. 2001). The Type A spawning has the effect of allowing several batches of eggs (possibly up to 7 or 8 – Claro and Lindeman 2003) to be released during one spawning aggregation. This is in contrast to the other type oocytes development process seen in snappers and groupers, Type D, in which oocytes develop all at the same rate but release at different rates and from 4-5 egg batches are released per spawning aggregation (Claro and Lindeman, 2003 and Garcia-Cagide et al. 2001).

Smith (1971) estimated fecundity for a single yellowfin grouper to be 1,425,443 eggs at about 51 cm TL. Eggs and larvae are planktonic, larvae settling out from one week to two or three months (Sutherland et al. 1986 citing the work of Smith 1971).

Taylor and McMichael (1983) reported fecundity estimates for two fish collected off Florida to be  $1,994,740 \pm 26,734$  oocytes (70 cm) and  $2,874,665 \pm 12,966$  (72 cm).

## 2.9. Maturation Size

Garcia et al (1994), using data from Thompson and Munro (1978) from Jamaica, calculated maturation size for females to be 51 cm TL for Cuban fish. Thompson and Munro (1978) reported sex ratios of mature (i.e., >51 cm) yellowfin grouper from unexploited oceanic banks off Jamaica, to be M:F = 1.18:1. Tuz-Sulub et al. (2006) microscopically examined yellowfin grouper from Campeche Bank (n=363, range 39 to 92 cm TL). They observed that most specimens (males and females) were reddish in color with rounded dark blotches on the sides of the body and small dark red spots on the ventral head and body (Figure 5). These authors reported no transitional fish. Taylor and McMichael (1983) observed mature male yellowfin grouper at 54 cm SL in the Florida Keys.

### 2.9.1. Timing of Spawning

On the Grammanik Bank south of St. Thomas, U.S. Virgin Islands spawning occurs from February through April, apparently with peaks occurring in March with full moon (Nemeth, 2004a). Munro et al. (1975) and Smith (1960) both citing Erdman (1956) indicated that ripe specimens were observed in Puerto Rican waters in April. Yellowfin grouper were reported to spawn off Jamaica from February through April (Chan and Sadovy 2002; Thompson and Munro, 1978) and off Cuba from January through June (Garcia-Cagide et al. 1994). Tuz-Sulub et al. (2006) observed yellowfin grouper spawning during spring, March to May, off Campeche Mexico.

Yellowfin grouper spawn off Bermuda in July, in the Florida Keys during March, and on the Florida Middle Grounds (off West Florida in the eastern Gulf of Mexico) from March to August (Bullock and Smith, 1991; Heemstra and Randall, 1993; Taylor and McMichael, 1983). Heyman and Revena. (2003) reported a February-June spawning period for yellowfin grouper

populations in the Mesoamerican Barrier Reef Systems (MBRS) with peak spawning occurring in March and April.

### 2.9.2. Sexual Dimorphism

Tuz-Sulub et al. (2006) documented sexual dichromatism in yellowfin grouper spawning aggregations from Campeche Bank (Mexico). Males were observed to have a bright yellow blotch on both sides of the lower jaw while the majority of spawning females retained a reddish lower jaw (Figure 8.) In their samples, histological examination of the gonads confirmed males were 25% of the total and ranged in size from 39-92 cm TL (n=90) and females, 75% of the total number observed, ranged from 43-85 cm TL (Figure 9, Table 3). No transitional fish were observed. Of the 90 males examined histologically, 97% of these (n=87) had the bright yellow blotch on the lower jaw, and ranged in size from 62 cm TL - 92 cm TL; the remaining 3 males were 39, 45, and 61 cm TL in length and did not have the lower jaw yellow coloration. The authors noted that all males were sexually active (ripening, ripe-running, or spent) and that 80% of the females were. The remaining 20% of the females were immature or resting, however no further details were provided regarding size of these non-sexually active females.

### 2.9.3. Spawning Aggregation (SPAG) Information

Several studies have reported that the yellowfin grouper aggregates at some of the same sites utilized by the tiger, Nassau, and black groupers (Sadovy *et al.* 1994, Beets and Friedlander 1992, Fine 1990). It is worth noting that most of the data relating to yellowfin grouper spawning aggregations has obtained ancillary to field studies being conducted for mainly the Nassau grouper, *Epinephelus striatus*, and secondarily more recently from studies of the tiger groupers off Puerto Rico. Luckhurst (2003) provided a summary as to status of SPAGs for a number of snappers and groupers. The results from these studies were reviewed and the information on SPAGs for the yellowfin grouper summarized as to locations and status where information was available.

### 2.9.4. U.S. Virgin Islands

Olsen and LaPlace (1978) in their study of the Nassau grouper and red hind aggregation about eight miles off the south coast of St. Thomas (U.S. Virgin Islands) between 1974 and 1978, made a brief mention of the occurrence of yellowfin grouper aggregations on the same site immediately after cessation of spawning by these two species. Although, the Nassau and red hind had apparently been exposed to intense fishing for the previous 25 years, Olsen and LaPlace (1979) suggested that the yellowfin population in that area was 'at near zero fishing effort exposure'. Anecdotal reports suggest that the absence of a directed fishery was probably due to the perception held by many fishers that yellowfin grouper from this area were ciguatoxic (J. Magner, President STFA, pers. com.). Although, not definitive this information could suggest that the yellowfin grouper population off St. Thomas (US Virgin Islands) was not undergoing intense exploitation in the late 1970's.

Sadovy et al. (1994) also reported that other aggregating sites existed for the yellowfin grouper off the US Virgin islands but had not been fully documented. Since that time, three additional aggregation sites have been documented off the US Virgin Islands and have received extensive study. Sites located north and south of St. Thomas are utilized from February through

April. A third site located in the Virgin Islands National Park off St. John, is utilized year-round. Individuals aggregating at that site number about 200 (Rielinger 1999). Nemeth (2004a, b) has been studying grouper (i.e., red hind, yellowfin, tiger, and Nassau groupers) spawning aggregations off St. Thomas since 2000

#### 2.9.5. Puerto Rico

In Puerto Rico, yellowfin grouper aggregations have been observed off Vieques Island and among tiger grouper aggregations in the El Seco area. The first reports of yellowfin grouper aggregations in this area occurred in the early 1980's from observations made by divers who reported large aggregations of tiger grouper off the eastern end of Vieques (Matos-Caraballo 1997, Sadovy et al., 1994). These concentrations of groupers were undergoing intense fishing as far back as the early 1970's. Sadovy et al. (1994) also noted that an aggregation area for yellowfin grouper existed north of Vieques Island.

A multi species grouper spawning aggregation site at Mona Island, Puerto Rico is frequented by *M. venenosa* in addition to *M. tigris* and *E. guttatus*. This aggregation site is located at the shelf escarpment in a colonized pavement hardbottom habitat at 30-40 m depth. Yellowfin grouper have been observed aggregated from January through March, although surveys haven't been conducted in April at this aggregation site (M. Schärer, pers. com.).

Research divers at a deep water (40 m) aggregation site at Bajo de Sico, off the west coast of Mayagüez (Puerto Rico) have reported *M. venenosa*, *M. tigris* and *E. striatus* aggregating together (Estéves pers. com.). This site has been seasonally protected during January through February since 1996 in federal waters, although the local jurisdiction waters of this area protection has been changed to a prohibition for *E. guttatus* throughout the Puerto Rico insular platform.

#### 2.9.6. Cayman Islands and Honduras

During field studies evaluating Nassau grouper aggregations off the Cayman Islands, Whaylen et al. (2004) observed small groups of yellowfin grouper aggregating (but not spawning) on the same site at night. Divers observed small groups, usually from 2-4 individuals, present at the time as Nassau and tiger grouper, the latter two species observed spawning. The grouper aggregations off the Little Cayman (east end) have been fished since about 1903, intensely in the mid 1980's and since 1995 there was no Nassau aggregation at Little Cayman. Whaylen et al. (2006) reported yellowfin grouper aggregating (but not spawning) on the west end of Little Cayman however, data on abundance of these sightings was not given.

Fine (1990, cited in Sadovy et al. 1994) suggested that yellowfin grouper and tiger grouper used the same sites off Guanaja, Honduras.

#### 2.9.7. Cuba

Claro and Lindeman (2003) provided empirical information on reefish aggregation sites off Cuba's coast for 21 sites where several snapper and groupers species commonly were reported aggregating by scientists and commercial fishers between 1970 and 2000. All of these sites were located at the shelf break in depths of 20-50 m. Claro and Lindeman (2003) noted that published information on spawning sites in that region was unavailable for almost all species on



the Cuban shelf. They obtained their data through interviews of commercial fisherman, often made in conjunction with other scientific studies. Only sites with unusually large catches of fishes with running-ripe or enlarged gonads during known spawning peaks were identified as potential spawning aggregation sites. Yellowfin grouper were reported aggregating at nearly all of the 21 sites and spawning aggregations were reported at one site off the southwestern coast (Puntalon de Cayo Guano). Also present with yellowfin grouper were spawning groups of the black and Nassau grouper. These species aggregated there from December to March, spawning with peak spawning occurring at different times for each species. Claro and Lindeman's tabled data indicated that over the 30 year study period, 1970-2000, that qualitatively, general the size of the yellowfin grouper spawning aggregations had declined at the majority of the sites where yellowfin were known to occur. The authors emphasized that the spatial and quantitative information obtained regarding these aggregation was a result of fishing effort and validation effort. Information was presented on location, habitat type at the site, spawning peak by species, time of spawning, lunar period, and gear actively used on the aggregation.

#### 2.9.8. Mexico

Tuz-Sulub *et al.* (2003) presented the first evidence on the formation of aggregations for *M. venenosa* from a spawning site off "Bajos Del Norte" about 137 miles northeast of Progreso Port, Mexico (Campeche Bank). The area is characterized by a range of submarine mountain-like reef formations, and ranges from about 5-20 m. Tuz-Sulub (2003) reported that grouper aggregations at this site had been fished at least since the late 1990's during February each year. The catch for groupers, done during five days of fishing in February 2001 at Bajos Del Norte, reached a total of 2.4 metric tons. Yellowfin grouper were reported spawning there along with the tiger and black groupers and red hind.

#### 2.9.9. Belize

Sala *et al.* (2001) provided baseline information on the multi-species nature of the grouper spawning aggregations on Glover's Reef (Belize) and emphasized the need for immediate attention to the other grouper species observed at these sites. The grouper complex found at Glover's Reef includes the yellowfin, the tiger, and the black groupers as well as a large number of snappers, grunts, jacks and other reef fish species (in all there were over 20 species present). Sala *et al.* (2001) noted that information is lacking on the sizes of the grouper spawning aggregations throughout the Caribbean as well as the temporal variability in the aggregation size, in-particular, in these other grouper species. These authors reported that historically a minimum of some 14 sites existed off Belize's barrier reefs and offshore reefs where a complex of groupers, the Nassau grouper, black, yellowfin and a variety of snappers, jacks, and grunts were known to aggregate for spawning. Heyman and Requena reported yellowfin grouper occurring at four of these known grouper.

In 2002, the Belize government enacted regulations that halted fishing in 11 traditional offshore spawning areas and also established a four-month closed season for grouper fishing ([http://news.nationalgeographic.com/news/2003/03/0304\\_030304\\_belizefish.html](http://news.nationalgeographic.com/news/2003/03/0304_030304_belizefish.html)). In addition, off Belizean waters 12 marine protected areas are contained within the reef and seven of these have been designated UNESCO World Heritage status.

During 2003, monitoring of grouper spawning aggregations by Belizean scientists at three of the historically active sites (i.e., Nicholas Caye, Caye Glory (Emily), Rocky point, Sand Bore (Lighthouse Reef) continued as well as one new site was surveyed (Belize fisheries Department, 2005). This research was recommended by the Technical Working Group as an element within the component of Promoting Sustainable Use of the Mesoamerican Barrier Reef Systems (MBRS) and, the sub-component of Promoting of Sustainable Fisheries Management under the 2003-2004 MBRS Annual Work Plan to monitor spawning aggregation sites (Belize Fisheries Dept, 2005). Yellowfin grouper and two other common *Mycteroperca* groupers known to co-occur with the yellowfin, the tiger and the black grouper were both observed during these dives. Precise estimates of the numbers of yellowfin grouper were not available however; the plotted data suggest that less than 100 individuals were observed at any site.

The Belizean Nassau grouper SPAG evaluation case example is particularly relevant in the examination of the health of the yellowfin grouper in the U.S. Caribbean. To summarize the current status of information on the yellowfin grouper, Domeier et al. (2002) wrote, “*Mycterperca venenosa* - is a large species with poorly know aggregations, uses multi-species sites, exploited in many areas”. Similar spawning aggregation information and additional biological information (abundance, site location, tagging data, emigration rates, socio-economic, etc.) such as obtained in the Belizean studies for the Nassau grouper and in the US Virgin Islands for the red hind, are critically needed to quantify and describe spawning aggregations of the yellowfin, tiger, and black groupers. Interestingly, Whaylen et al. (2006) wrote “the locations of many of the Nassau grouper spawning aggregations have been know for at least a century “, yet information remains lacking for many of the other grouper species. An excellent source of information pertaining to methodology and protocol in use in the Mesoamerican quantifying information on reef fish aggregations can be found in MBRS (2004) and Heyman et al. (2004) and at <http://www.reefresilience.org/r2spawning/index.htm>, at <http://www.scrfa.org/server/home/index.htm> \and <http://www.mbrs.org.bz/dbdocs/tech/Protocol16.pdf> .

All of the above examples suggest that throughout the range of the yellowfin grouper, aggregations have declined. An immediate need exists to further quantify the available information from the published and unpublished literature and to conduct new field studies to document and study spawning aggregations of the yellowfin, tiger, and black groupers, including location, duration of aggregation (timing), number of individuals by site locale, size, reproductive condition, sex ratios, biological metrics (individual size or length), depths of aggregation location, periodicity in aggregation timing, social behaviors characteristics of the aggregation, and population removal (extraction) information both historical and present-day, and habitat and environmental conditions (e.g., MBRS 2004, Heyman et al. 2002, Johannes et al. 1994). Although information from throughout the species range is vital to any comprehensive analysis of yellowfin grouper population status throughout the species range, of immediate need to the SEDAR14 and subsequent management process for the US Caribbean resource, would be to quantify such spawning aggregation information for the U.S. Caribbean (Puerto Rico and St. Croix geological platform) yellowfin grouper population.

## 2.10. Natural Mortality (M)

Munro and Williams (1985) reported  $M$  for fish sampled off Jamaica to be 0.42 per year. Thompson and Munro (1978) reported a range for  $M$  to be 0.23-0.61, for yellowfin grouper captured at unexploited oceanic banks off Jamaica, corresponding to the range of values for  $K$  of 0.10-0.27. These authors utilized the Beverton and Holt (1956) formulation to calculate  $M$ , the latter computes  $M$  from the relative abundances of successive length groups. Ault et al. (2005) calculated  $M$  to be 0.20 using the method of Alagaraga (1984), the latter procedure the author indicated was 0.20 based on lifespan.

Alternatives methods of estimating  $M$  was considered, in particular the ‘rule of thumb’ estimator of Hoenig, 1983) and the regression approach of Hewitt and Hoenig (2004). Both methods require information on longevity of the species. Froese and Pauly (2007) reported  $t_{max}$  for the yellowfin grouper to be 14 years. Using that value  $M$  estimated from the ‘rule of thumb’ approach would be 0.21.  $M$  estimated from the regression method would be 0.31.

## 2.11. Conservation Issues

The yellowfin grouper is considered, according to the International Union for the Conservation of Nature and Natural Resources (IUCN), as “Near Threatened”<sup>1</sup>. This determination was made by the IUCN based on a review of the trends in landings and spawning aggregations throughout the species distribution (range) that included Bermuda, the US (mainly Caribbean), Cuba, Mexico and Belize. Percentage declines of landings of 80% were observed between 1975 and 1981 in Bermuda, and 94% in the US Caribbean from 1990-2001. Off Cuba, Mexico and Belize the size of spawning aggregations declined also. Large declines in commercial landings of this species have been reported, concomitant with increases in fishing intensity throughout the range, however in many regions information is lacking to document spawning aggregations. This species is particularly vulnerable to fishing pressure during spawning aggregation formation. Based on the available information on fishery declines and spawning aggregation information, the IUCN Red List has also identified the yellowfin grouper as close to a “Vulnerable” listing<sup>2</sup> under IUCN criteria A2d, and in addition highlights the need for more data and more effective management. A schematic of the IUCN designation categories and criteria is presented in Figure 10. (<http://www.iucnredlist.org/search/details.php/44683/all>).

Based on criteria contained within the Sustainable Fisheries Act of the Caribbean Fishery Management Council (CFMC), FMP the yellowfin grouper stock in the U.S. Caribbean is undergoing Overfishing. The CFMC recently enacted regulations to prohibit harvest of any fish from February 1 through April 30, for yellowfin grouper within the Grammanik Bank area off St. Thomas, U.S. Virgin Islands. The Grammanik Bank is an area that has been closed to fishing seasonally since 1990, and permanently since 1999 to protect spawning red hind. The recent total harvest regulation was specifically designed to protect known spawning aggregations of the yellowfin grouper in that area. The decline of the yellowfin grouper spawning aggregation in this area was documented to have begun around 2002-2003 (Nemeth 2004b).

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<sup>1</sup> Near Threatened: “A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.”

<sup>2</sup> Vulnerable: “A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.”

Mexico also has responded to concern for the status of this species, with a closure from January 15 to February 15 on the Campeche Bank, a minimum size regulation of 30 cm TL, and an annual catch quota of 1,200 mt for the Cuban fleet of all groupers (SEMARNAP cited in IUCN Red list document).

Largest conservation concerns include spawning stock overfishing and habitat destruction, and the general lack of quantitative information to quantify population status throughout the species range. Possible steps suggested for reversing population declines include incorporating known spawning aggregation sites into management planning, including the development of long term spatially comprehensive monitoring programs. In addition, imposing specific gear restrictions on particularly vulnerable fish populations was recommended (Luckhurst 2003).

The status of the yellowfin grouper has not been assessed relative to the pre-Sustainable Fisheries Act (SFA) definitions of overfished and overfishing. Under these definitions, the stock would be overfished when the transitional SPR is less than 20% SPR. Overfishing is defined as a fishing mortality rate in excess of that corresponding to a 20% SPR level (NMFS 2002). This species is managed together with the red, black, misty, yellowedge, and tiger groupers in Grouper Unit 4. The SFA Working Group classified the status of Grouper Unit 4 as “at risk (Final Rule for the Fisheries of the Caribbean, Gulf of Mexico, and South Atlantic; Comprehensive Amendment to the Fishery Management Plans of the U.S. Caribbean, 2005)

The yellowfin grouper is thought by some scientists to have low population resilience, to be very vulnerable to fishing gear, particularly during spawning aggregation period, thus very susceptible to overfishing. In addition, estimates of the minimum population doubling time are from 4.5 to 14 years (Froese and Pauly, 2007).

## 2.12. Other Issues of Interest

There have been frequent reports that the yellowfin grouper can cause ciguatera or fish poisoning (Haalstead et al., 1990 cited in Froese and Pauly, 2007; Olsen and laPlace, 1978; Bohlke and Chaplin, 1968 cited in Brownell and Rainey, 1971). Although, individuals from the Bahamas and the Virgin Islands have been recognized as ciguateric, this species traditionally was a desirable food fish and even large individuals, 5 to 10 kgs in size, from locales considered safe were sold and consumed. Some researchers consider this species to be more frequently associated with ciguatera poisoning than other groupers ([http://research.myfwc.com/gallery/image\\_details.asp?id=13233](http://research.myfwc.com/gallery/image_details.asp?id=13233)). Bohlke and Chaplin (1968) noted that the yellowfin grouper was the only Bahaman grouper known to be cause ciguatera.

## 2.13. Research Recommendations

The life history subgroup made several research recommendations pertaining to yellowfin grouper. These are prioritized below.

### 2.13.1. Early life history

- 1) Conduct studies on temporal (intra- and inter-annual) variability of oceanographic processes in relation to larval dispersal to quantify the degree of connectivity between platforms of the currently managed stock units.
- 2) Examine early larval dispersal patterns (post fertilization to pre-flexion) using genetic markers.
- 3) Identify essential habitats according to life history stage, including critical recruitment and post-settlement (nursery) habitats.

#### 2.13.2. Adult Populations

- 4) Identify additional past and present spawning aggregation sites and characterize migration corridors.
- 5) Define the spatial scale of migrations by individuals participating in spawning aggregations through tag and release studies.
- 6) Evaluate the potential to use visual census data obtained from spawning aggregations as fisheries independent data for assessing stock status (i.e. sex ratio, average size, density) and for monitoring populations.

#### 2.13.3. Stock Identification

- 7) Investigate population genetic structure of yellowfin grouper “stocks” within the US Caribbean and in relation to the wider Caribbean.
- 8) Examine ontogenetic shifts in habitat usage and diel foraging patterns

#### 2.14. Tasks to be accomplished (Soon)

- 1) For each life history sub section where parameter estimates are provided- indicate which one or range of values the group recommends. Done
- 2) For the values of M—calculate using the Lorenzen approach

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Figure 1. Photo of Yellowfin grouper, *Mycteroperca venenosa*. Reprinted from Fishbase 2007. Submitted by Robert A. Patzner.



Figure 2. Yellowfin grouper on cleaning station, showing distinct yellow coloration on the pectoral fin, from the Caymans. [Photograph taken by Jonathan Powel: <http://www.reefnews.com/reefnews/news/v06/v06n08/moraygpr.html>].



Figure 3. Yellowfin grouper displaying distinct red coloration, in the Caymans. [Photograph taken by Jonathan Powell: <http://www.reefnews.com/reefnews/news/v06/v06n08/moraygpr.html>].



Figure 4. Computer Generated Native Distribution Map of *Mycteroperca venenosa* (un-reviewed) Distribution: Western Atlantic: Bermuda, Gulf of Mexico and the Caribbean south to Sao Paulo, Brazil. Central and south American coasts to Guianas (Ref. 26938). [Reprinted from Fishbase 2007].



Figure 5. Adult yellowfin grouper observed during diving off Bahamas .  
[Copyright Don Chestnut, ©2005, contact@ drches01@uky.edu].



Figure 6. Yellowfin grouper, *Mycteroperca venenosa*  
International Underwater Spearfishing Association (IUSA),  
World Record 14.06 kg., 31 lbs, April 30, 2006, R. Reyes  
Location: Carolina, Puerto Rico, ©Copyright 2007 IUSA.



Figure 7. 40 lb Yellowfin grouper, *Mycteroperca venenosa*, caught off Palm Beach, Florida  
Memorial Day, 2006. Photo taken by Teresa Travis.





FIG. 2. Colour variations on the lower jaw of male and female yellowfin grouper from Bajos del Norte and Cayo Arenas, Campeche Bank, Mexico: (a) 870 mm total length ( $L_T$ ) male with bright yellow blotch ( $\Rightarrow$ ) on lower jaw and (b) 740 mm  $L_T$  female with reddish lower jaw ( $\Rightarrow$ ).

Figure 8. Photographs of yellowfin grouper sampled from Campeche Bank, Mexico illustrating sexual dichromatism. Reprinted from Tuz-Sulub et al.(2006).

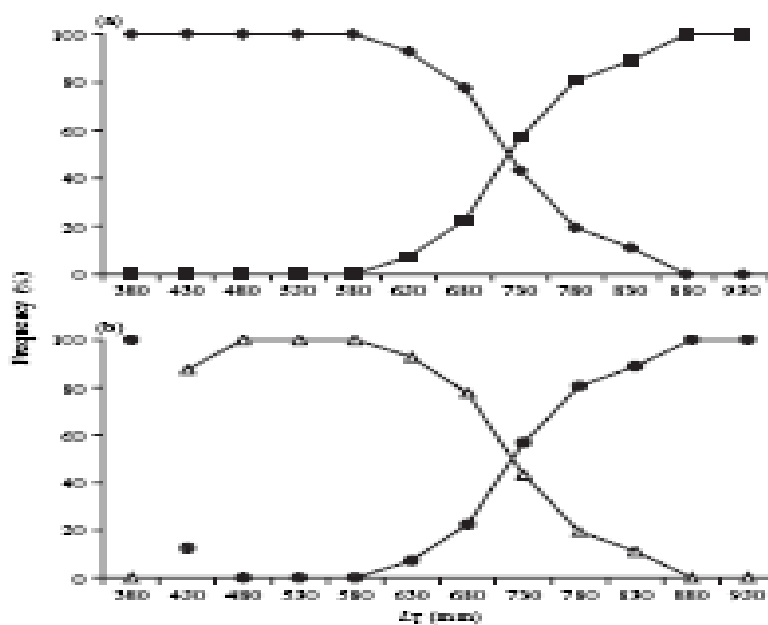


FIG. 9. Size-frequency distribution for yellowfin grouper from Bajos del Norte and Cayo Arenas, Campeche Bank, Mexico. (a) Individuals with (■) or without (○) bright yellow blotch on lower jaw and (b) male (●) and female (○) fish.

Figure 9. Size frequency information of yellowfin grouper by a) dichromatic type (with or without identifying yellow blotch on lower jaw) and by b) sex (male, female). Reprinted from Tuz-Sulub et al. (2006).

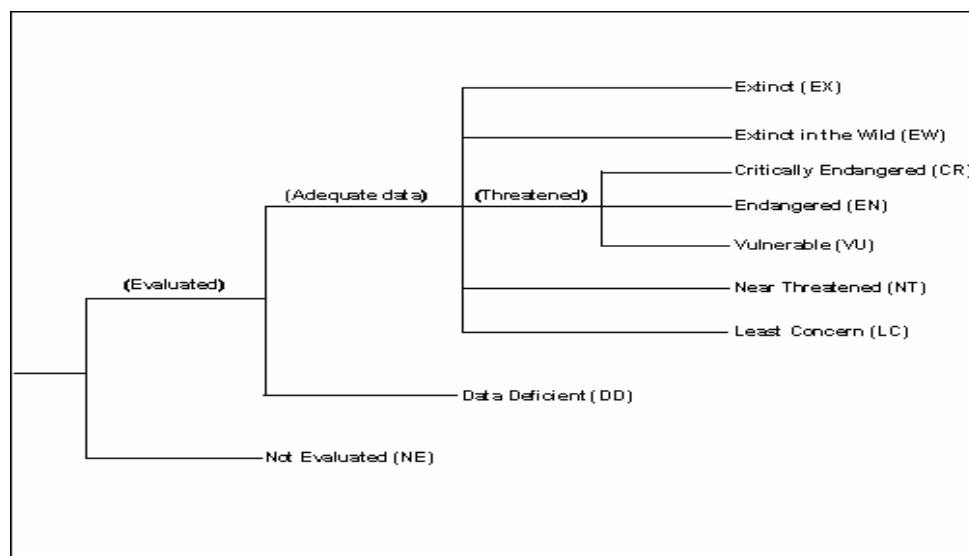


Figure 10. Structure of the IUCN Listing Categories [From: [http://www.iucnredlist.org/info/categories\\_criteria2001](http://www.iucnredlist.org/info/categories_criteria2001) ].

Table 1. Yellowfin grouper, *Mycteroperca venenosa*, weight – length equation parameters (Tabled data reprinted from Froese and Pauly (2007), equation form =  $\log(\text{Weight}) = \log(a) + b * \log(\text{Length})$ ).

a	b	Sex	Length (cm)	Len_Unit	n	Country	Locality
0.0198	2.976	unsexed	22.0 - 55.0	FL	19	Puerto Rico	
0.0269	2.980	unsexed	31.0 - 69.0	TL	36	Cuba	Southwest Zone
0.0122	3.000	unsexed	25.0 - 64.0	FL	11	US Virgin Is.	St. Croix
0.0132	3.040	unsexed	25.0 - 92.0	TL	54	Cuba	Southwest Zone
0.0069	3.140	unsexed	28.0 - 90.0	FL	103	US Virgin Is	St.T./St. J.

Where present, parameter estimates for U.S. Caribbean are preferred for analysis of U.S. Caribbean populations.

Table 2. Yellowfin grouper, *Mycteroperca venenosa*, length conversion formulae (Tabled data reprinted from Froese and Pauly (2007), equation form =  $\text{Unknown Length} = a + b * \text{Known Length}$ ).

Unknown Len Unit		Known		Unit	Len Range (cm)	Sex	
a	b	a	b				
SL	0.310	0.880	TL	25	-	54	Unsexed
TL	0.000	1.031	FL	-	-	-	unsexed
TL	0.000	1.037	FL	-	-	-	unsexed
TL	0.000	1.051	FL	-	-	-	unsexed
TL	1.000	1.160	SL	26	-	77	Unsexed
TL	0.000	1.208	SL	-	-	-	unsexed
TL	0.000	1.304	SL	-	-	-	unsexed
TL	0.000	1.327	SL	-	-	-	unsexed

Table 3. Information on size and sexual dichromatism recorded for yellowfin grouper, *Mycteroperca venenosa*, from Campeche Bank, Mexico. Tabled data reprinted from Tuz-Sulub et al. 2006).

TABLE I. Number of males and females with or without bright yellow blotch on lower jaw, by total length class, for yellowfin grouper caught between March and May 2002 and 2004 at Bajos del Norte and Cayo Arenas, Campeche Bank, Mexico

$L_T$ class (mm)	Males			Females	
	$n^a$	$n$ with bright yellow blotch	$n$ without bright yellow blotch	$n^a$	$n$ without bright yellow blotch
360–400	1	0	1	0	0
410–450	1	0	1	7	7
460–500	0	0	0	26	26
510–550	0	0	0	51	51
560–600	0	0	0	56	56
610–650	5	4	1	64	64
660–700	13	13	0	45	45
710–750	21	21	0	16	16
760–800	25	25	0	6	6
810–850	16	16	0	2	2
860–900	7	7	0	0	0
910–950	1	1	0	0	0
Total	90	87	3	273	273

<sup>a</sup>Sex determined from histological sections of gonads.

### 3. Commercial Statistics

#### 3.1. Fishery Dependent Data

The Working Group included Hector Lopez, Luis Rivera and Andy Maldonado from Puerto Rico, William Tobias and Jimmy Magner from the Virgin Islands, Graciela Molinar from the Caribbean Fishery Management Council, Josh Bennett and Steve Turner from the NOAA Fisheries Service in Miami. The group was later joined by other participants including Wes Toller and David Olsen from the Virgin Islands and Nancie Cummings from NOAA Fisheries. Steve Turner was the overall leader and Graciela Molinar lead reporting on recreational fisheries.

#### 3.2. Commercial Fishery (may be subdivided by gears/fleets) (TOR 4, 5)

##### 3.2.1. Commercial Landings

###### 3.2.1.1. Puerto Rico

The Department of Natural Environmental Resources, Fisheries Statistics Program has primary responsibility for the collection of fisheries statistics for the Commonwealth of Puerto Rico. Fishery landings have been collected annually since 1967; landings information for some years in the 1950s and early 1960s. Landings from 1967-1982 apparently exist, but were not available to the working group.

Fisheries landings were collected from voluntarily reporting fishermen until 2004 when reporting became mandatory (however after 2003 some fishermen continued to not report – see section 2.1.1.3). Total landings are calculated by expanding reported landings to account for the proportion of fishermen who did not report.



### Species identification

Cummings (SEDAR14 DW 7) referring to Matos (2004) states that mutton snapper is at times confused with deep water snappers. One participant in the working group from Puerto Rico indicated that in general landings of valuable snappers such as mutton were accurately identified while landings of less valuable species might be aggregated.

Cummings (pers. comm.) indicated that the identification of yellowfin grouper in Puerto Rican landings was thought to be reliable.

### Reported landings

Reported Puerto Rican landings since 1983 for queen conch, mutton snapper and yellowfin grouper are shown in Tables 1-3.

Conch landings are reported as meat weights. In 2003 fishermen began cleaning conch (removing the head and viscera). The working group was told that about 50% of the conch landings in 2003 were cleaned and that by 2004 all fishermen were thought to have been reporting cleaned conch weight. A conversion factor of 1.5 was recommended for calculating uncleaned weight from cleaned weight (G. Molinar pers. comm.).

The conch landings included in this report have NOT been corrected for this change; it is recommended that analyses using these data correct for this change. The working group recommended that consideration be given to determining when individual ports changed from reporting uncleaned to reporting cleaned conch and that the correction factor be applied on a port by port basis until all ports were thought to be reporting cleaned conch.

### Sampling fractions and Under/Over reporting

Puerto Rican landings are tabulated from voluntary fishermen's reports. The total number of fishermen is thought to be known from mandatory licenses. The annual reporting fractions (reporting fishermen / licensed fishermen) for 1972-2005 are shown in Table 4. To calculate total landings, reported landings are divided by the annual, island-wide sampling fraction.

Matos (2004b) reported that there were instances when the landings reported by individual fishermen differed from what was actually landed, and this finding was corroborated by Puerto Rican fishermen and port agents at the meeting. Apparently there are a number of reasons why a fisherman might prefer to record less or more landings than actually made. The degree of under-reporting and over-reporting was not known. No adjustments of mis-reporting were made by the SEDAR 14 Data Workshop.

### Calculated total landings

Total landings in Puerto Rico for conch, mutton snapper and yellowfin grouper are shown in Table 5-7. The yellowfin grouper landings are not presented by gear because of potential confidentiality issues; over all years the dive, hook and line and trap fisheries have dominated the landings.

The U.S. Virgin Islands landings statistics have not recorded landings by species, so only landings of finfish are included in this report (see below). For comparison the total Puerto Rican landing of all finfish combined are presented in Table 8.

#### 3.2.1.2. Virgin Islands

The largest islands of the United States Virgin Islands (USVI) are St. Thomas, St John and St Croix. St Thomas and St John are on the same platform as Puerto Rico and the British Virgin Islands. St. Croix is on a different platform 40 miles south of St. Thomas / St. John and separated by a deep oceanic trench.

The Government of the Virgin Island began requiring the reporting of commercial landings in 1972-1973. The first USVI reported landings in the database are from 1974. The Virgin Islands Code requires that commercial fishers submit catch reports on an annual basis for every day fished as a requirement for annual license renewal. The Division of Fish and Wildlife requests that the catch reports be submitted on a monthly basis. In recent years approximately 200 fishers were registered in the island group of St. Croix (173 in 2005-2006) and approximately 175 in St. Thomas/St. John (178 in 2005-2006). Since 1990, this number has remained relatively stable. However, prior to 1990, the number of registered fishers showed greater variability for both island groups and especially for St Thomas/St John (Figure 1).

Data collected for the purpose of monitoring fisheries landings have generally been species specific for conch and lobster while for finfish the landings were reported in aggregated gear categories (hookfish, potfish, trapfish,...) before the mid/late 1990s and in species groups since then.

In any given year some licensed fishermen reported landings for only some months and some licensed fishermen did not reported at all. Therefore for conch both reported landings and calculated total landings are presented. Additionally calculated total landings of finfish are presented for comparison with Puerto Rico.

Biological sampling in the Virgin Islands has recorded information on the entire catch of finfish by species. The numbers of mutton snapper and yellowfin grouper measured are presented as are the associated length compositions.

#### Species identification

Finfish are not recorded by species in U.S. Virgin Islands landings statistics.

Conch landings primarily reflect captures of queen conch. Some whelk landings have in the past been combined with conch landings, however the proportion of whelk in the total landings is thought to be quite low.

#### Reported Landings

The total amount of conch landings reported by cooperating Virgin Island fishers is shown in Table 9 by island group and gear.

### Under Reporting and Expansion Factors

The annual reporting rate by fishers has varied greatly since 1974. In particular, the proportion reporting has varied from < 20% for St. Croix in several years in the 1970s to > 90% for both island groups (Figure 2) in most recent years (97% in St. Croix in 2005-2006 and about 80% in St. Thomas / St. John). A substantial portion of this inter-annual variability is attributed to discontinuities and irregularities in administrative oversight of the landings program. Since about 1990, the Division of Fish and Wildlife resumed administrative responsibility of the program and reporting frequency has steadily improved to the present high levels.

Adjustments (expansion factors) were used to correct for non-reporting as part of the estimation of total landings by commercial fishers. Non-reporting by commercial fishers falls into two overlapping classes. Class I - Fishers who failed to submit one or more of the required 12 monthly reports within any year. Class II - Fishers who obtained licenses but failed to submit all monthly reports for a given fishing year. The strategy to develop appropriate expansion factors had to account for both classes of non-reporting.

To address the first type of non-reporting (Class I), a correction factor for missing monthly reports was developed. This factor replaces missing information with average landings derived from reported information on a fisher-by fisher basis. It assumes that of individual reporting fishermen the landings within months that were reported are representative of the landings within months that were not reported. For example, if a fisher reported zero landings for 10 months and did not report for two months, the remaining two months were replaced with zero landings. If a fisher reported an average of 100 lbs of landings per month for 10 months, then 100 lbs was assumed for each of the two missing months.

The Class I correction assumes that reporting behavior was similar among months. This assumption was verified by examination of reporting trends during periods of low, intermediate and high reporting compliance (Figure 3).

The Class I expansion factors, which correct for partial year reporting by individual fishers, were calculated in the following manner.

Given:

$R_{iyf}$  as the number of monthly reports submitted by a fisher (f) from an island group (i, either St Thomas / St John or St Croix) in a year (y).

$W_{iyfm}$  as the weight of landings reported by a fisher in a month (may be 0 for some months).

Then the Class I expansion factor ( $E1$ ) is:

$$E1_{iyf} = 12 / R_{iyf}$$

and the expanded weight ( $W'$ ) per fisher is :

$$W'_{iyf} = \sum_m W_{iyfm} * E1_{iyf}$$

To address the second type of non-reporting (Class II, licensees who never reported within a year), expansion factors were calculated for two periods: one for 1991-2005 and one for

the earliest year through 1990 due to the concern that the proportion of fishers reporting no landings appeared to be unusually low in most years before 1991 (see above). Considerable uncertainty exists about this expansion factor, because of concerns that the proportion of non-reporters who did not fish might have been higher than the proportion of reporting fishermen who did not fish.

Let:

$L_{iy}$  be the number of licenses issued for an island group in a year

$F_{iy}$  be the number of fishers who filed at least one report for an island group in a year

$P_{iy}$  be the number of fishers who filed at least one report and reported some landings

$Z_{iy}$  be the number of fishers who filed at least one report but reported no landings in any report.

Then the 1991-present expanded landings are:

$$W''_{iy} = \sum_f W'_{iyf} * \frac{L_{iy}}{F_{iy}}$$

For 1990 and earlier, the 1991-2005 data were used to calculate the proportion of reporting fishers,  $p$ , which reported no landings:

$$p = \frac{\sum_{y=1991}^{2005} Z_{iy}}{\sum_{y=1991}^{2006} P_{iy}}$$

$$Z'_{iy} = p * P_{iy}$$

Then the Annual expansion factor,  $E2$ , is:

$$E2_{iy} = \frac{L_{iy}}{P_{iy} + Z'_{iy}}$$

and the estimated total expanded landings are:

$$W''_{iy} = \sum_f W'_{iyf} * E2_{iy}$$

The effective expansion factors derived using the reported and calculated total landings (calculated total / reported) are shown in Table 10 and Figure 4 for the two island groups (St. Thomas / St. John and St. Croix). In some years differences can be observed between the sampling fractions for conch and finfish. Those differences must be due to differences in the number of monthly reports by fishermen landing finfish and fishermen reporting conch (class 1 expansion factors) because those expansion factors are calculated for each fisherman while the annual expansion factor is calculated for the entire fleet for each island group.

### Calculated total landings and uncertainty

Total landings were calculated from the reported landings as defined above. The calculated total landings of conch by island group are shown in Table 11. The calculated total landings of all finfish by island group are shown in Tables 12 and 13.

### 3.3. Commercial Discards

In general all sizes of fish caught by commercial fishers are retained in Puerto Rico and the Virgin Islands. In the Virgin Islands feasibility studies for measuring bycatch in a pilot observer program were conducted in 2005-2006 and showed that considerable numbers of finfish were being discarded. A size limit was established for conch in 1988 in St. Croix and in 1994 in St. Thomas / St. John, but because conch are primarily harvested by hand (divers), it is thought that nearly all are of legal sizes.

Matos *et al.* (in press-a) indicated that conch, mutton snapper and yellowfin grouper were all discarded in Puerto Rico. In the relatively small number of trips reported on in Matos *et al.* mutton snapper were observed being discarded in trammel net and trap fisheries, and Matos (pers. comm.) noted that discarding of mutton snapper may have increased in recent years, because of recent management measures including a closed season for several snappers. No conch or yellowfin grouper were observed being discarded in the beach seine, hood and line, trammel net and trap fishing observed by Matos *et al.* Conch are thought to be released alive (Matos pers. comm.)

Studies in the Virgin Islands to determine the feasibility of collecting daily catch reports with species specific information on landings and discards have recorded mutton snapper discards off St. Thomas / St. John (MRAG 2007a); both mutton snapper and yellowfin grouper are also known to be discarded off St. Thomas / St. John primarily in the southeast section off those islands and to decreasing extent further west (Olsen, pers comm.). During a comparable study on St. Croix (MRAG 2006b), discards of sub-adult mutton snapper were recorded but no yellowfin grouper were observed in catches or discards. As in Puerto Rico, recent species specific area closures off the Virgin Islands are thought to have increased discarding (Olsen, pers. comm.). Ongoing research by the St. Thomas Fishermen's Association from 1500 trips and 80,000 trap hauls, indicates a discard rate of approximately 2 fish per trap haul. That survey indicates high discard rates of mutton snapper and some discarding of yellowfin grouper. The main reasons for discarding include the size of the fish being too small, the lack of a commercial market for the species or the presence of Ciguatera in the members of that species from the capture area.

### 3.4. Commercial Effort

Commercial fishing effort levels were not examined by the working group. Puerto Rican statistics primarily consist of reported trips (some aggregated trips can be identified in the data base) and U.S. Virgin Island landings statistics record individual trips. Both data bases are for reporting fishermen and would require expansion to calculated total fishing effort.

### 3.5. Biological Sampling

Biological sampling of commercial landings has been conducted for many years both in Puerto Rico and the Virgin Islands. In Puerto Rico substantial numbers of finfish have been measured annually, while in the Virgin Islands funding limitations have resulted in recent years in which few or no fish were measured. Very little information on the sizes of commercially harvested conch exist for either Puerto Rico or the U.S. Virgin Islands.

Available samples were filtered to remove potentially erroneous observations. Filtering was done to remove lengths which were considered above or below normal lengths for the species and weights which were out of range given the observed length and a length:weight equation (Bohnsack and Haper 1988).

#### 3.5.1. Puerto Rico

##### 3.5.1.1. Number of samples

The number of mutton snapper with accepted measurements in Puerto Rico by gear are shown in Table 14 and the number of yellowfin grouper are shown in Table 15. The proportion of length measurements of mutton snapper rejected through filtering as described above was often 3-4%, though in two years (1986 and 1990) roughly 15% was excluded and in most years during 1992-1997 6-9% was excluded.

Very few or no conch have been measured; no tabulations were made.

##### 3.5.1.2. Sampling Intensity

Sampling fractions for the Puerto Rican fisheries were calculated from the number of fish measured and the number of fish landed as derived from the calculated total landings given above.

Sampling fractions for Puerto Rico have ranged from less than 0.1% to well more than 5% in a few strata. Generally the largest mutton snapper fishery, hook and line, has been sampled at roughly 1% in most years since about 2000 and the second largest fishery, trap, continues to be sampled at roughly 0.1% to 0.5% (Table 16). Landings of yellowfin grouper were quite low (Table 7), and the annual sampling fractions were quite variable. There were many years when sampling did not occur, but when it did occur sampling fractions by gear were often above 1%. Over all years the first and third most important fisheries for yellowfin grouper, dive and trap, have been sampled at 1%-2% while the second most important yellowfin grouper fishery, hook and line, has been sampled at less than 0.1%.

##### 3.5.1.3. Length distributions

The length frequency distributions for mutton snapper caught by the Puerto Rican hook and line, seine and trap fisheries are shown in Figures 5-7. Length frequency distributions for yellowfin grouper from the trap fishery for 1983 – 1991 are shown in Figure 8.

##### 3.5.1.4. Adequacy for characterizing the catch

Spawning area closures for snappers and groupers have been implemented in recent years. Those restrictions could have resulted in changes in the size composition and catch rates of mutton snapper and yellowfin grouper.

### 3.5.2. Virgin Islands

#### 3.5.2.1. Number of samples

The numbers of mutton snapper and yellowfin grouper landed in St. Thomas / St. John with accepted length measurements are presented in Table 17 and the numbers for St. Croix are presented in Table 18.

Very few or no conch have been measured; no tabulations were made.

#### 3.5.2.2. Sampling Intensity

Sampling intensity for mutton snapper and yellowfin grouper landed in the Virgin Islands were not calculated because species specific landings are not available.

#### 3.5.2.3. Length distributions

The length frequency distributions for mutton snapper are shown for the St. Croix hook and line fishery in Figure 9 and for the St. Thomas / St. John and St. Croix trap fisheries in Figures 10 and 11. The length frequency distributions for yellowfin grouper for the St. Thomas / St. John and St. Croix trap fisheries in Figures 12 and 13.

#### 3.5.2.4. Adequacy for characterizing catch

In about 1993 the government of the Virgin Islands prohibited fishing on spawning aggregations. The size composition of mutton snapper and yellowfin grouper landed during the spawning season could differ before and after that prohibition went into effect.

### 3.6. Commercial Catch-at-Age/Length

Age and length composition of the entire catch were not created.

### 3.7. Comments on adequacy of data for assessment analyses

The empirical expansion factors used to calculate total landings from fishermen's reports and the associated assumption that non-reported trips are similar to reported trips suggest that there is probably considerable uncertainty about the total landings for conch in both Puerto Rico and the U. S. Virgin Islands and for mutton snapper and yellowfin grouper in Puerto Rico. The effective expansion factor for the Virgin Islands in recent years has been relatively lower (1.1 to 1.4) than in the past (Table 10), and as a result the conch landings from the St. Croix management group are probably more reliable than in earlier years.

Prior to 1987 landings in Puerto Rico of various snapper species may have included multiple species (Matos *et al.* in press-b). Some uncertainty exists as to whether mutton snapper may at times be included with other species or other species called mutton snapper; the working group believed that in general mutton snapper landings reflected the actual landings of that species.

As noted above, the Puerto Rican landings of conch since 2003 have not been corrected for the change in reporting uncleaned flesh weight to reporting cleaned flesh weight. For use in stock assessment, the landings need to be corrected for this change (see section 2.1.1.3)

Absence of species specific information for finfish on the Virgin Island's commercial landings will make it difficult to perform conventional stock assessments which require information on the total catch for mutton snapper and yellowfin grouper.

Absence or low level of size composition sampling for the Virgin Islands in many years will make it difficult to perform size based assessment analyses.

Various area and spawning season closures could result in shifts in observed size composition and catch rates. Care should be exercised when analyzing such fishery dependent data sets to consider such potential effects.

### 3.8. Research Recommendations

Continuous biological sampling in the Virgin Islands at sufficient levels to adequately characterize size and age composition.

Link biostatistical data for a fishing trip from Puerto Rico to all of the landings records for that trip.

Ensure that the catch and effort data of individual fishers in Puerto Rico can be identified over time.

Eliminate the need for expansion factors by obtaining information on all landings.



Table 1. Reported ('as landed') Puerto Rican commercial landings of conch in pounds by gear. An asterisk (\*) indicates that landings were reported but are not shown to protect possible confidentiality. A dash (-) indicates that no landings were reported. Prior to 2003, all landings presumably are uncleaned conch, thus including head and viscera in the reported weights. In 2003 fishermen who accounted for about 50% of the landings began cleaning conch (removing head and viscera) and by 2004 all fishermen were cleaning conch; the landings data presented here have not been adjusted for any changes in cleaning.

	diving	traps	other	total
1983	399,665	*	*	399,880
1984	294,773	-	-	294,773
1985	258,716	1,096	1,013	260,825
1986	185,972	1,409	979	188,360
1987	142,994	-	-	142,994
1988	213,173	6,754	10,780	230,707
1989	148,078	5,519	6,654	160,251
1990	104,305	3,047	623	107,975
1991	106,331	1,261	506	108,098
1992	87,436	1,793	1,729	90,958
1993	158,085	3,408	3,119	164,612
1994	158,579	7,480	4,788	170,847
1995	202,408	4,346	7,528	214,282
1996	227,192	5,279	7,395	239,866
1997	225,620	2,860	10,168	238,648
1998	244,920	2,774	13,261	260,955
1999	206,643	3,018	4,439	214,100
2000	269,182	2,953	9,243	281,378
2001	236,286	5,288	3,373	244,947
2002	225,790	8,034	1,873	235,697
2003	184,738	2,666	760	188,164
2004	212,312	1,475	2,405	216,192
2005	193,483	484	1,734	195,701

Table 2. Reported commercial landings of mutton snapper in Puerto Rico in pounds whole weight. Landings of finfish in the Virgin Islands are not recorded by species. Other gear includes seines, trammel nets, longline and unknown.

	diving	gill nets	hook and line	traps	other	total
1983	3,013	3,368	16,221	37,564	4,975	65,141
1984	570	3,322	15,966	26,793	6,435	53,086
1985	1,141	6,260	15,247	19,956	3,029	45,633
1986	2,868	6,434	8,098	11,162	1,776	30,338
1987	1,151	3,334	6,990	6,221	2,363	20,059
1988	2,251	3,158	9,195	5,227	1,723	21,554
1989	4,189	2,714	13,179	9,065	2,609	31,756
1990	3,502	2,542	10,906	7,005	1,237	25,192
1991	3,689	4,424	19,259	11,861	2,906	42,139
1992	2,029	2,020	16,565	9,160	2,742	32,516
1993	3,209	2,283	12,615	8,720	2,532	29,359
1994	2,205	3,829	18,497	9,432	5,766	39,729
1995	3,140	6,781	51,302	14,183	4,529	79,935
1996	3,489	9,901	40,662	15,809	6,601	76,462
1997	3,433	9,625	38,448	18,087	7,009	76,602
1998	5,086	7,629	40,341	18,817	5,564	77,437
1999	5,146	10,988	53,277	22,671	4,295	96,377
2000	6,224	15,221	40,245	21,404	3,784	86,878
2001	5,990	12,371	44,677	20,303	5,282	88,623
2002	8,234	11,987	43,830	22,139	5,717	91,907
2003	4,159	7,083	44,317	19,693	4,820	80,072
2004	6,109	4,554	19,165	13,928	3,387	47,143
2005	5,097	2,356	16,057	8,790	1,261	33,561

Table 3. Reported commercial landings of yellowfin grouper in Puerto Rico in pounds whole weight. Landings of finfish in the Virgin Islands are not recorded by species. An asterisk (\*) indicates that landings were reported but are not shown to protect confidentiality. A dash (-) indicates that no landings were reported.

	total
1983	-
1984	-
1985	-
1986	-
1987	*
1988	460
1989	1,249
1990	559
1991	1,702
1992	921
1993	1,483
1994	448
1995	827
1996	1,617
1997	2,088
1998	1,793
1999	3,350
2000	2,298
2001	3,641
2002	6,916
2003	4,893
2004	2,189
2005	753

Table 4. Sampling fractions representing the annual proportion of Puerto Rican fishermen which reported landings. These were used to calculate total landings from reported landings for Puerto Rico.

1972	0.60	
1973	0.60	
1974	0.60	
1975	0.60	
1976	0.60	
1977	0.60	
1978	0.68	Weiller and Suarez-Caabro, 1980
1979	0.75	Calderon, 1983 (Coop. Sci Rpt) and Collazo and Calderon
1980	0.75	Calderon, 1983 (Coop. Sci. Rpt) and Collazo and Calderon
1981	0.75	Calderon, 1983 (Coop. Sci. Rpt) and Collazo and Calderon
1982	0.75	Calderon, 1983 (Coop. Sci. Rpt) and Collazo and Calderon
1983	0.61	Calderon, 1983 (Coop. Sci. Rpt) and Collazo and Calderon
1984	0.59	Garcia-Moliner 1986
1985	0.56	Garcia-Moliner 1986
1986	0.75	Matos-Caraballo and Rivera-Alvarez, 1994
1987	0.75	Matos-Caraballo and Rivera-Alvarez, 1994
1988	0.56	Matos-Caraballo and Sadovoy, 1990 (Tech Rpt)
1989	0.51	Matos-Caraballo and Sadovoy, 1990 (Tech Rpt)
1990	0.51	Matos-Caraballo and Sadovoy, 1990 (Tech Rpt)
1991	0.51	Matos-Caraballo and Sadovoy, 1991
1992	0.60	Matos-Caraballo, 1993 (p 5)
1993	0.60	Matos-Caraballo, 1994 (p 4)
1994	0.64	Matos-Caraballo, 1998
1995	0.71	Matos-Caraballo, 1998
1996	0.71	Matos-Caraballo, 1998
1997	0.78	Matos-Caraballo, 1998
1998	0.78	Matos-Caraballo, 1998
1999	0.78	Matos-Caraballo, 2000 (Coop. Sci. Rpt.)
2000	0.57	Matos-Caraballo, 2002
2001	0.68	Matos-Caraballo, 2002
2002	0.86	Matos-Caraballo, 2004
2003	0.56	Matos-Caraballo, 2004
2004	0.61	Matos-Caraballo, 2004
2005	0.50	Matos-Caraballo

Table 5. Calculated total landings of conch from Puerto Rico as landed (1983-2002 landings are uncleaned meats, while about 50% of 2003 and all of 2004-2005 are cleaned meats). An asterisk (\*) indicates that landings were reported but are not shown to protect possible confidentiality. A dash (-) indicates that no landings were reported.

	diving	traps	other	total
1983	654,309	*	*	654,309
1984	499,038	-	-	499,038
1985	461,559	1,952	1,803	465,314
1986	247,461	1,872	1,301	250,634
1987	190,140	-	-	190,140
1988	379,584	12,014	19,175	410,773
1989	289,578	10,788	12,996	313,362
1990	203,928	5,952	1,213	211,093
1991	207,584	2,451	981	211,016
1992	145,267	2,980	2,871	151,118
1993	262,854	5,668	5,182	273,704
1994	246,788	11,646	7,451	265,885
1995	283,709	6,079	10,566	300,354
1996	318,563	7,407	10,377	336,347
1997	288,018	3,642	13,007	304,667
1998	312,940	3,545	16,975	333,460
1999	263,941	3,854	5,649	273,444
2000	470,975	5,163	16,187	492,325
2001	346,077	7,735	4,935	358,747
2002	261,141	9,320	2,143	272,604
2003	328,259	4,740	1,333	334,332
2004	345,709	2,404	3,921	352,034
2005	386,966	968	3,468	391,402

Table 6. Calculated total landings of mutton snapper from Puerto Rico in pounds whole weight.

	diving	gill nets	hook and line	seine	traps	other	total
1983	4,899	5,462	26,309	6,428	61,049	1,657	105,804
1984	950	5,582	26,850	8,603	45,023	2,245	89,253
1985	2,018	11,076	27,011	2,160	35,333	3,218	80,816
1986	3,784	8,493	10,679	1,422	14,731	921	40,030
1987	1,513	4,389	9,198	1,940	8,184	1,170	26,394
1988	3,965	5,567	16,196	1,371	9,148	1,674	37,921
1989	8,125	5,213	25,533	3,416	17,537	1,661	61,485
1990	6,753	4,916	21,092	1,578	13,502	822	48,663
1991	7,105	8,539	37,256	2,579	22,893	3,060	81,432
1992	3,337	3,324	27,409	2,740	15,108	1,795	53,713
1993	5,277	3,767	20,769	3,266	14,382	916	48,377
1994	3,380	5,914	28,556	3,701	14,503	5,215	61,269
1995	4,343	9,453	71,647	2,135	19,590	4,137	111,305
1996	4,801	13,724	56,625	2,100	21,761	7,052	106,063
1997	4,265	12,052	48,601	2,154	22,527	6,637	96,236
1998	6,363	9,577	51,017	1,668	23,538	5,323	97,486
1999	6,439	13,791	67,508	1,543	28,408	3,847	121,536
2000	10,784	26,423	69,912	693	37,004	5,864	150,680
2001	8,633	17,877	64,818	3,963	29,159	3,681	128,131
2002	9,353	13,557	49,988	3,651	24,969	2,849	104,367
2003	7,229	12,352	78,382	4,363	34,372	4,116	140,814
2004	9,680	7,280	30,909	2,146	22,206	3,314	75,535
2005	10,194	4,712	32,114	462	17,580	2,060	67,122

Table 7. Calculated total landings of yellowfin grouper from Puerto Rico in pounds whole weight. An asterisk (\*) indicates that landings were reported but are not shown to protect confidentiality. A dash (-) indicates that no landings were reported.

	total
1983	-
1984	-
1985	-
1986	-
1987	*
1988	809
1989	2,433
1990	1,076
1991	3,310
1992	1,518
1993	2,457
1994	690
1995	1,148
1996	2,241
1997	2,648
1998	2,264
1999	4,243
2000	3,990
2001	5,281
2002	7,969
2003	8,667
2004	3,523
2005	1,506

Table 8. Calculated total landings of finfish in pounds whole weight from Puerto Rico. An asterisk (\*) indicates that landings were reported but are not shown to protect confidentiality. A dash (-) indicates that no landings were reported.

	Puerto Rico										
	cast nets	diving	gillnet	hook and line	long line	seine	trammel net	trap	nets	multiple	unknown
1974	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-
1983	26,315	178,544	672,774	1,357,314	48,176	348,159	-	2,534,512	-	-	-
1984	*	147,370	571,693	962,303	44,653	247,686	-	2,288,946	-	-	*
1985	33,519	111,204	646,338	1,321,928	39,234	184,734	*	1,785,772	-	-	*
1986	17,069	82,523	474,928	1,049,216	12,909	118,804	-	1,055,622	-	-	-
1987	24,227	81,116	399,480	779,072	15,926	153,143	*	896,859	-	-	*
1988	10,163	141,477	456,467	1,129,185	41,223	162,735	*	917,105	-	-	*
1989	16,647	164,193	436,895	1,435,232	50,201	242,446	21,457	1,372,390	-	-	2,137
1990	11,031	153,213	521,616	1,417,778	54,505	166,498	138,100	1,190,167	-	-	282
1991	33,385	178,553	630,055	1,509,966	38,573	237,032	256,184	1,227,428	-	-	-
1992	24,715	118,624	248,947	1,206,755	30,202	135,806	392,880	789,338	-	-	-
1993	21,669	154,977	397,202	1,464,192	46,135	168,581	421,378	869,451	-	-	-
1994	43,251	149,658	471,783	1,573,435	31,096	136,101	242,807	928,496	-	-	-
1995	39,345	213,750	424,303	2,199,639	55,080	194,234	293,927	987,732	-	-	-
1996	34,021	197,932	499,840	1,901,299	68,606	168,138	392,453	920,486	-	-	-
1997	36,370	182,934	568,594	1,862,952	72,569	157,072	288,566	924,909	-	-	-
1998	*	245,694	502,889	1,595,872	94,032	84,425	267,035	773,310	-	-	*
1999	40,341	218,245	564,307	1,602,034	84,141	80,151	182,226	685,030	-	-	-
2000	54,961	361,134	743,406	2,167,708	205,999	103,903	137,659	871,336	-	-	-
2001	37,961	314,827	647,422	1,894,209	75,306	113,227	76,961	925,619	-	-	-
2002	31,269	279,389	511,235	1,369,599	61,402	98,123	84,251	648,092	-	-	-
2003	27,760	186,546	452,832	1,699,737	56,051	129,807	126,500	714,357	-	-	-
2004	25,367	192,880	257,956	1,113,956	39,662	107,096	82,945	459,304	-	-	-
2005	*	189,322	175,226	1,448,532	41,884	37,460	53,500	376,966	-	-	*



Table 9. Reported landings of conch in the U.S. Virgin Islands in pounds of uncleaned meat. An asterisk (\*) indicates that landings were reported but are not shown to protect confidentiality. A dash (-) indicates that no landings were reported.

	St. Thomas / St. John			St. Croix		
	diving	unknown and other	total	diving	unknown and other	total
1974	-	*	*	-	-	-
1975	-	2,161	2,161	-	*	*
1976	-	*	*	-	657	657
1977	-	741	741	-	7,737	7,737
1978	-	2,439	2,439	-	17,302	17,302
1979	-	6,598	6,598	-	4,978	4,978
1980	-	4,197	4,197	-	12,315	12,315
1981	-	2,728	2,728	-	21,306	21,306
1982	-	4,190	4,190	-	16,878	16,878
1983	-	7,954	7,954	-	12,699	12,699
1984	-	5,540	5,540	-	24,224	24,224
1985	-	3,827	3,827	-	16,196	16,196
1986	-	6,036	6,036	-	8,576	8,576
1987	-	6,502	6,502	-	20,058	20,058
1988	-	743	743	-	9,253	9,253
1989	-	*	*	-	4,060	4,060
1990	-	-	-	-	14,276	14,276
1991	-	-	-	-	41,876	41,876
1992	-	*	*	-	18,622	18,622
1993	-	5,387	5,387	-	26,416	26,416
1994	-	1,889	1,889	-	36,682	36,682
1995	-	1,478	1,478	*	35,698	35,698
1996	-	2,601	2,601	13,571	22,379	35,950
1997	*	1,606	1,606	33,738	13,635	47,372
1998	715	*	715	59,471	4,544	64,015
1999	1,620	*	1,620	49,693	2,534	52,226
2000	1,083	*	1,083	72,461	4,488	76,949
2001	1,847	*	1,847	110,017	3,427	113,444
2002	2,172	*	2,172	113,141	3,401	116,542
2003	2,555	784	3,339	105,946	2,258	108,204
2004	1,022	*	1,022	123,281	1,977	125,258
2005	429	*	429	149,724	6,325	156,049

Table 10. Effective expansion factors for the Virgin Islands.

	St. Thomas / St. John		St. Croix	
	finfish	conch	finfish	conch
1974	12.70			
1975	4.04	5.09	22.29	18.65
1976	7.75	13.14	10.31	12.50
1977	2.03	1.79	3.62	6.16
1978	1.54	1.70	3.94	4.04
1979	1.78	3.62	4.84	11.20
1980	2.69	2.98	7.95	7.91
1981	3.07	2.81	6.75	6.47
1982	2.30	2.63	2.70	2.61
1983	1.70	1.76	1.77	1.65
1984	1.54	1.64	1.46	1.45
1985	1.80	1.85	5.03	1.49
1986	1.86	1.92	2.82	4.76
1987	1.89	1.77	1.55	1.75
1988	1.31	1.26	2.14	1.96
1989	1.36	1.39	6.97	11.55
1990	1.54		2.03	2.28
1991	1.77		1.69	1.94
1992	1.51	1.58	1.53	1.58
1993	1.44	1.53	1.50	1.62
1994	1.40	1.61	1.31	1.53
1995	1.33	1.36	1.27	1.48
1996	1.12	1.11	1.50	1.73
1997	1.22	1.21	1.23	1.35
1998	1.49	1.62	1.23	1.27
1999	1.26	1.24	1.35	1.42
2000	1.24	1.24	1.33	1.35
2001	1.19	1.21	1.17	1.23
2002	1.11	1.12	1.08	1.09
2003	1.25	1.21	1.33	1.23
2004	1.14	1.49	1.35	1.34
2005	1.23	1.23	1.45	1.40

Table 11. Calculated total landings of conch in the U.S. Virgin Islands in pounds of uncleaned meat. An asterisk (\*) indicates that landings were reported but are not shown to protect confidentiality. A dash (-) indicates that no landings were reported.

St. Thomas / St. John		St. Croix		
	total	diving	unknown and other	total
1974	*	-	-	-
1975	10,991	-	*	*
1976	*	-	8,210	8,210
1977	1,327	-	47,639	47,639
1978	4,151	-	69,957	69,957
1979	23,900	-	55,753	55,753
1980	12,488	-	97,410	97,410
1981	7,655	-	137,755	137,755
1982	11,030	-	44,055	44,055
1983	14,011	-	20,938	20,938
1984	9,111	-	35,240	35,240
1985	7,068	-	24,124	24,124
1986	11,584	-	40,784	40,784
1987	11,527	-	35,171	35,171
1988	938	-	18,155	18,155
1989	*	-	46,876	46,876
1990	-	-	32,539	32,539
1991	-	-	81,156	81,156
1992	*	-	29,515	29,515
1993	8,233	-	42,857	42,857
1994	3,042	-	55,987	55,987
1995	2,014	*	*	52,761
1996	2,892	60,034	1,980	62,014
1997	2,020	58,723	5,035	63,758
1998	1,158	74,268	6,955	81,223
1999	2,011	70,652	3,343	73,995
2000	1,344	97,574	5,976	103,550
2001	2,237	135,572	4,116	139,688
2002	2,423	122,821	4,326	127,147
2003	4,056	130,182	3,091	133,273
2004	1,524	165,068	2,856	167,924
2005	526	209,450	9,433	218,883

Table 12. Calculated total landings of finfish in pounds whole weight from the island group St. Thomas / St. John. An asterisk (\*) indicates that landings were reported but are not shown to protect confidentiality. A dash (-) indicates that no landings were reported.

	St. Thomas / St. John											
	cast nets	diving	gillnet	hook and line	long line	seine	trammel net	trap	nets	multiple	unknown	total
1974	-	1,174	-	24,241	-	-	-	592,415	39,451	-	-	657,281
1975	-	11,780	-	59,958	-	-	-	886,321	89,501	-	-	1,047,560
1976	-	7,074	-	206,772	-	-	-	1,424,104	79,146	-	-	1,717,096
1977	-	*	-	81,444	-	-	-	344,589	57,189	-	*	483,732
1978	-	4,075	-	50,617	-	-	-	434,865	138,233	-	-	627,790
1979	-	7,700	-	75,028	-	-	-	535,332	176,141	-	-	794,201
1980	-	25,475	-	128,011	-	-	-	958,470	221,039	-	-	1,332,995
1981	-	13,552	-	117,666	-	-	-	1,145,048	149,024	-	-	1,425,290
1982	-	10,143	-	70,902	-	-	-	820,602	106,459	-	-	1,008,106
1983	-	13,210	-	70,474	-	-	-	727,846	82,717	-	-	894,247
1984	-	13,720	-	102,258	-	-	-	690,963	64,884	-	-	871,825
1985	-	6,571	-	123,861	-	-	-	843,144	77,109	-	-	1,050,685
1986	-	4,129	-	158,525	-	-	-	763,923	95,902	-	-	1,022,479
1987	-	1,676	-	171,785	-	-	-	702,743	51,522	-	-	927,726
1988	-	1,522	-	160,695	-	-	-	550,554	60,327	-	12,619	785,717
1989	-	7,244	-	143,000	-	-	-	496,249	74,703	-	12,426	733,622
1990	-	4,436	-	131,087	-	-	-	458,871	80,875	-	-	675,269
1991	-	1,532	-	184,373	-	-	-	600,354	177,643	-	99	964,001
1992	-	5,597	-	214,950	-	-	-	625,023	90,911	-	14,301	950,782
1993	-	8,513	-	207,605	-	-	-	579,613	191,760	-	25,734	1,013,225
1994	-	8,903	-	209,246	-	-	-	538,942	120,968	-	24,551	902,610
1995	-	5,778	-	192,107	-	-	-	453,701	113,673	-	22,502	787,761
1996	-	5,727	-	137,339	-	-	-	375,028	73,471	-	14,397	605,962
1997	1,450	12,347	*	181,507	-	5,975	-	477,040	69,056	105	*	768,294
1998	8,181	8,057	*	173,320	-	29,366	-	531,375	42,314	1,577	*	801,630
1999	17,376	10,141	*	169,970	-	51,353	-	397,297	7,735	2,052	*	656,577
2000	8,401	8,021	*	217,908	-	64,449	-	365,170	-	155	*	664,552
2001	7,737	7,001	*	258,290	-	74,742	-	430,287	-	3,800	*	782,215
2002	9,376	8,112	*	243,205	-	85,323	-	428,949	-	1,583	*	777,161
2003	15,473	11,087	*	220,678	-	79,192	-	510,959	-	1,636	*	839,407
2004	13,511	3,278	*	169,465	-	82,873	-	482,118	-	3,026	*	754,482
2005	7,873	8,831	*	163,621	*	82,820	-	475,907	-	19,024	*	758,469

Table 13. Calculated total landings of finfish in pounds whole weight from the island group St. Croix. Note that dive landings may include gill and trammel net landings, because at times divers use nets to fish. An asterisk (\*) indicates that landings were reported but are not shown to protect confidentiality. A dash (-) indicates that no landings were reported.

	St. Croix											
	cast nets	diving	gillnet	hook and line	long line	seine	trammel net	trap	nets	multiple	unknown	total
1974	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	6,507	-	-	-	299,130	39,743	-	-	345,380
1976	-	*	-	96,881	-	-	-	364,027	*	-	13,568	474,476
1977	-	*	-	50,760	-	-	-	124,233	*	-	8,345	183,338
1978	-	30,510	-	47,866	-	-	-	137,770	4,919	-	-	221,065
1979	-	12,531	-	33,602	-	-	-	262,277	20,823	-	-	329,233
1980	-	17,783	-	54,158	-	-	-	215,819	24,419	-	-	312,179
1981	-	19,596	-	209,166	-	-	-	319,589	41,975	-	-	590,326
1982	-	5,320	-	145,638	-	-	-	244,943	10,124	-	-	406,025
1983	-	8,176	-	113,805	-	-	-	269,074	12,584	-	-	403,639
1984	-	7,135	-	149,133	-	-	-	238,840	26,390	-	-	421,498
1985	-	4,408	-	115,665	-	-	-	695,502	15,129	-	-	830,704
1986	-	3,265	-	131,000	-	-	-	429,242	69,343	-	-	632,850
1987	-	14,339	-	152,996	-	-	-	368,382	56,793	-	-	592,510
1988	-	7,848	-	145,606	-	-	-	246,500	17,688	-	-	417,642
1989	-	52,148	-	76,975	-	-	-	421,313	49,361	-	-	599,797
1990	-	41,677	-	214,536	-	-	-	426,998	71,501	-	-	754,712
1991	-	38,267	-	305,127	-	-	-	424,828	66,581	-	-	834,803
1992	-	23,864	-	275,120	-	-	-	375,736	74,491	-	-	749,211
1993	-	75,136	-	335,536	-	-	-	349,400	111,341	-	-	871,413
1994	-	88,579	-	280,783	-	-	-	260,641	104,926	-	-	734,929
1995	*	36,470	*	205,707	-	-	-	180,215	117,179	-	1,793	543,161
1996	*	65,790	52,177	210,990	-	11,303	-	214,306	94,966	-	*	656,088
1997	*	49,237	102,100	237,851	-	37,698	-	228,119	25,292	26,880	*	713,520
1998	*	53,826	62,973	209,947	-	39,486	-	192,400	-	96,201	*	679,705
1999	*	83,069	120,199	259,714	-	38,105	-	214,003	-	59,216	*	775,768
2000	*	171,291	127,766	269,257	-	46,329	-	175,619	-	63,026	*	853,342
2001	*	150,700	122,413	310,984	-	43,359	-	164,017	-	113,453	*	906,011
2002	*	186,705	138,903	351,785	-	47,809	-	193,282	-	28,467	*	948,069
2003	*	265,586	151,011	374,824	-	36,903	-	148,100	-	52,266	*	1,031,764
2004	*	291,921	169,098	317,311	-	31,845	-	179,331	-	60,566	*	1,050,838
2005	*	393,127	161,079	383,917	-	62,855	44,040	172,771	-	35,442	*	1,253,807

Table 14. Numbers of mutton snapper with accepted length measurements from Puerto Rico by gear.

	<b>dive</b>	<b>gillnet</b>	<b>hook &amp; line</b>	<b>seine</b>	<b>trap</b>	<b>other</b>	<b>total</b>
1983	-	-	1	-	58	-	59
1984	4	-	26	-	216	5	251
1985	1	-	14	-	113	1	129
1986	-	16	16	66	113	8	219
1987	2	1	3	14	33	3	56
1988	3	8	26	24	49	50	160
1989	6	20	22	3	48	63	162
1990	5	105	48	54	43	22	277
1991	5	3	297	5	80	30	420
1992	13	-	203	88	34	55	393
1993	2	8	104	44	14	3	175
1994	1	1	38	38	8	-	86
1995	3	-	84	7	5	-	99
1996	4	-	10	2	6	-	22
1997	-	4	7	-	31	-	42
1998	12	13	106	52	28	2	213
1999	12	130	60	27	68	6	303
2000	11	-	141	73	66	3	294
2001	16	6	43	124	57	3	249
2002	8	-	162	170	100	15	455
2003	-	3	301	214	37	21	576
2004	9	4	138	202	42	1	396
2005	21	4	131	85	20	-	261
2006	9	-	13	196	6	-	224

Table 15. Numbers of yellowfin grouper with accepted length measurements from Puerto Rico by gear.

	<b>dive</b>	<b>hook &amp; line</b>	<b>trap</b>	<b>other</b>	<b>total</b>
1983	-	1	2	-	3
1984	1	1	29	-	31
1985	-	2	39	1	42
1986	4	4	25	5	38
1987	4	-	7	2	13
1988	3	4	19	1	27
1989	8	1	18	1	28
1990	1	7	-	-	8
1991	2	-	10	-	12
1992	-	3	-	5	8
1993	-	3	-	-	3
1994	-	1	-	-	1
1995	4	-	-	-	4
1996	-	-	-	-	-
1997	8	5	-	-	13
1998	-	1	-	-	1
1999	6	6	-	-	12
2000	21	3	1	-	25
2001	2	-	-	-	2
2002	1	3	-	-	4
2003	1	1	-	-	2
2004	1	-	-	-	1
2005	-	1	-	-	1
2006	-	-	-	-	-

Table 16. Mutton snapper sampling fractions from Puerto Rico.

	<b>dive</b>	<b>gillnet</b>	<b>hook &amp; line</b>	<b>seine</b>	<b>trap</b>
1983			0.0%		0.3%
1984	1.7%		0.3%		1.2%
1985	0.5%		0.4%		0.8%
1986		0.2%	0.8%	9.3%	3.6%
1987	0.2%	0.1%	0.2%	0.5%	1.8%
1988	0.3%	0.2%	0.6%	3.4%	1.3%
1989	0.5%	1.1%	0.3%	0.1%	0.3%
1990	0.4%	2.9%	1.0%	7.6%	0.6%
1991	0.4%	0.0%	3.6%	0.2%	0.3%
1992	2.3%		2.5%	4.8%	0.8%
1993	0.3%	0.3%	3.3%	2.4%	0.3%
1994	0.3%	0.0%	0.8%	1.6%	0.1%
1995	0.2%		0.4%	0.2%	0.1%
1996	0.6%		0.1%	0.1%	0.0%
1997		0.0%	0.1%		0.3%
1998	1.4%	0.1%	1.6%	4.2%	0.2%
1999	0.5%	0.5%	0.2%	1.6%	0.3%
2000	0.3%		1.2%	9.8%	0.3%
2001	0.6%	0.0%	0.3%	3.1%	0.5%
2002	0.1%		1.1%	5.8%	0.4%
2003		0.0%	1.0%	5.1%	0.1%
2004	0.3%	0.0%	0.8%	14.6%	0.2%
2005	0.6%	0.0%	1.8%		0.1%
2006					



Table 17. Numbers of mutton snapper and yellowfin grouper with accepted length measurements from St. Thomas / St. John by gear.

mutton snapper			yellowfin grouper				
	traps	other	total		traps	other	total
1983	-	-	-	1983	-	-	-
1984	38	2	40	1984	148	7	155
1985	87	17	104	1985	156	70	226
1986	13	-	13	1986	31	7	38
1987	7	-	7	1987	2	-	2
1988	-	-	-	1988	-	14	14
1989	-	-	-	1989	-	-	-
1990	-	-	-	1990	-	-	-
1991	6	-	6	1991	-	-	-
1992	2	-	2	1992	3	-	3
1993	4	-	4	1993	2	-	2
1994	4	-	4	1994	4	-	4
1995	-	2	2	1995	-	-	-
1996	-	-	-	1996	-	-	-
1997	-	-	-	1997	-	-	-
1998	-	-	-	1998	-	-	-
1999	-	-	-	1999	-	-	-
2000	-	-	-	2000	-	-	-
2001	-	-	-	2001	-	-	-
2002	13	5	18	2002	5	11	16
2003	3	-	3	2003	-	-	-
2004	2	-	2	2004	1	-	1
2005	39	-	39	2005	-	-	-
2006	22	-	22	2006	8	-	8

Table 18. Numbers of mutton snapper and yellowfin grouper with accepted length measurements from St. Croix by gear.

mutton snapper					yellowfin grouper			
	hook & line	traps	other	total		traps	other	total
1983	8	30	53	91	1983	12	12	24
1984	188	20	247	455	1984	13	31	44
1985	63	4	17	84	1985	16	36	52
1986	3	20	2	25	1986	45	4	49
1987	10	25	3	38	1987	38	1	39
1988	88	18	-	106	1988	48	-	48
1989	7	14	-	21	1989	42	-	42
1990	2	5	1	8	1990	2	1	3
1991	9	11	1	21	1991	5	3	8
1992	4	2	-	6	1992	4	-	4
1993	5	2	1	8	1993	-	-	-
1994	1	8	-	9	1994	5	1	6
1995	2	-	1	3	1995	-	-	-
1996	1	-	-	1	1996	-	-	-
1997	-	2	-	2	1997	-	-	-
1998	-	1	-	1	1998	1	-	1
1999	-	10	-	10	1999	-	-	-
2000	-	1	-	1	2000	-	-	-
2001	-	-	-	-	2001	-	-	-
2002	-	6	5	11	2002	3	-	3
2003	1	-	15	16	2003	-	1	1
2004	-	-	1	1	2004	-	-	-
2005	1	14	1	16	2005	-	-	-
2006	-	-	-	-	2006	-	-	-

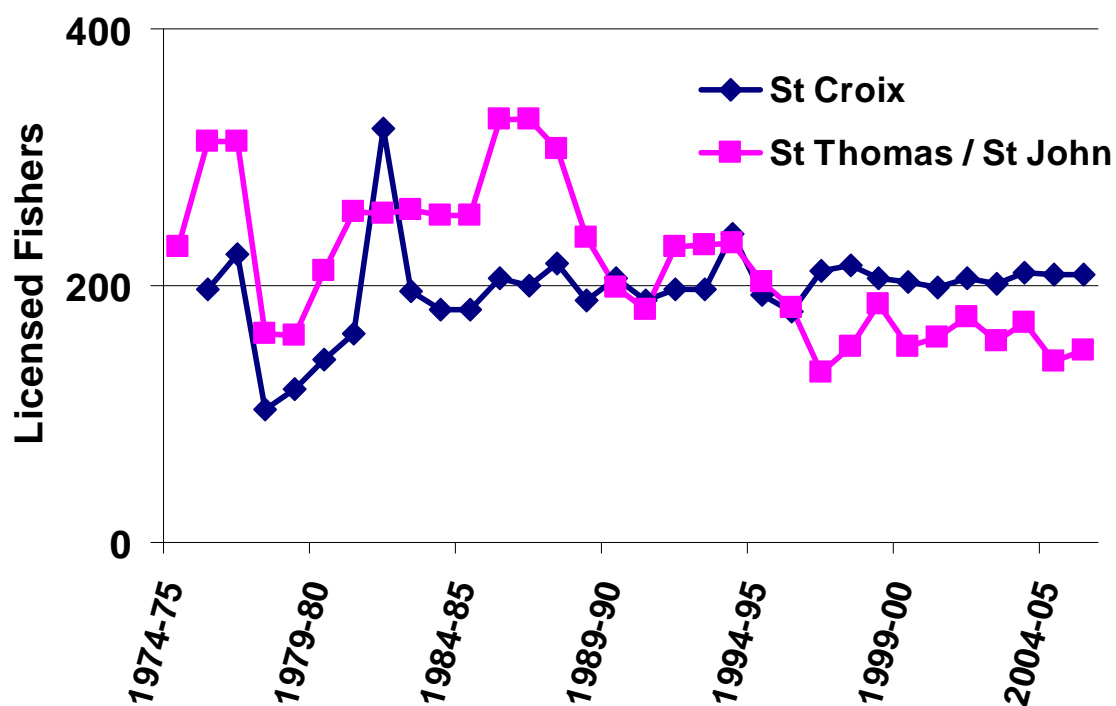


Figure 1. Number of licensed fishers in the Virgin Islands since 1974.

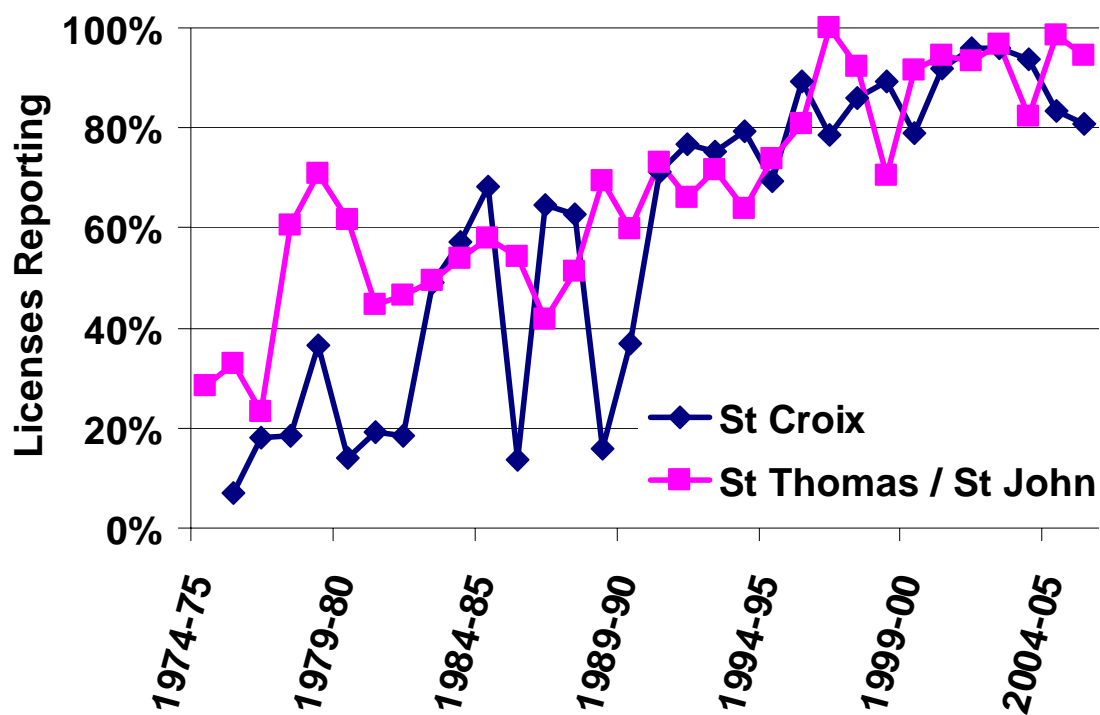


Figure 2. Percentage of Virgin Island license holders who reported landings.

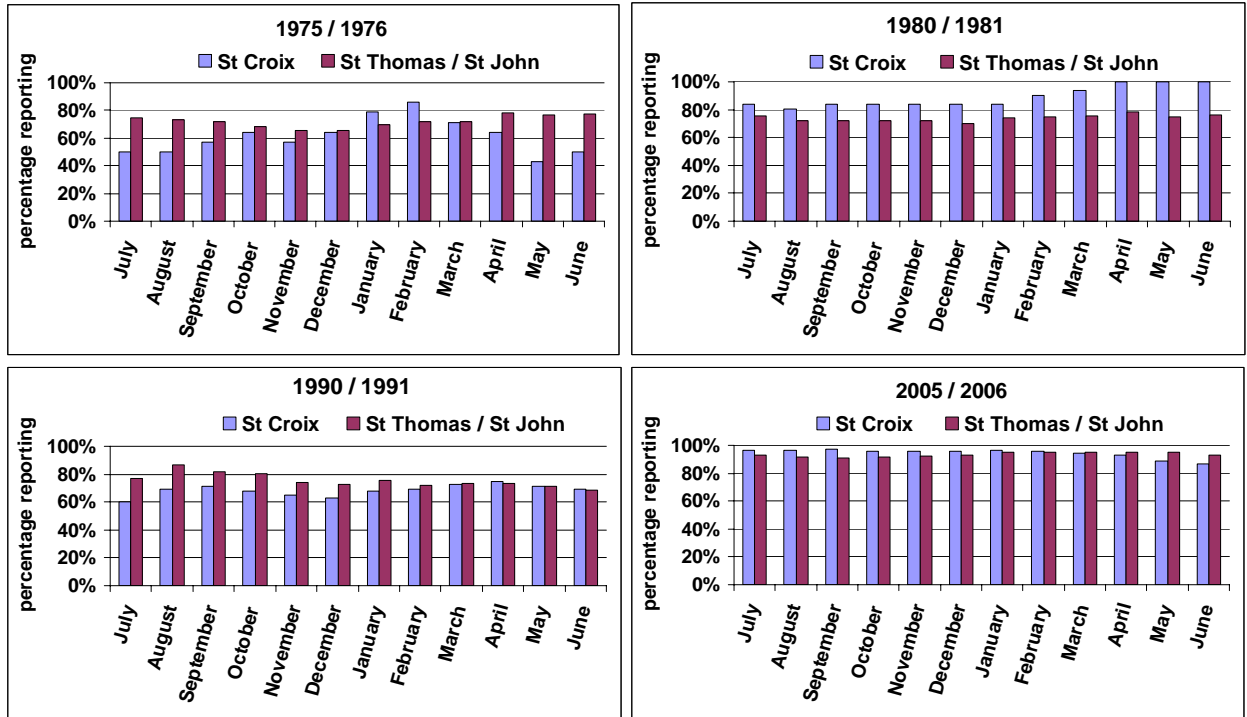


Figure 3. Percentage of licensed fishermen reporting by month for four fishing years.

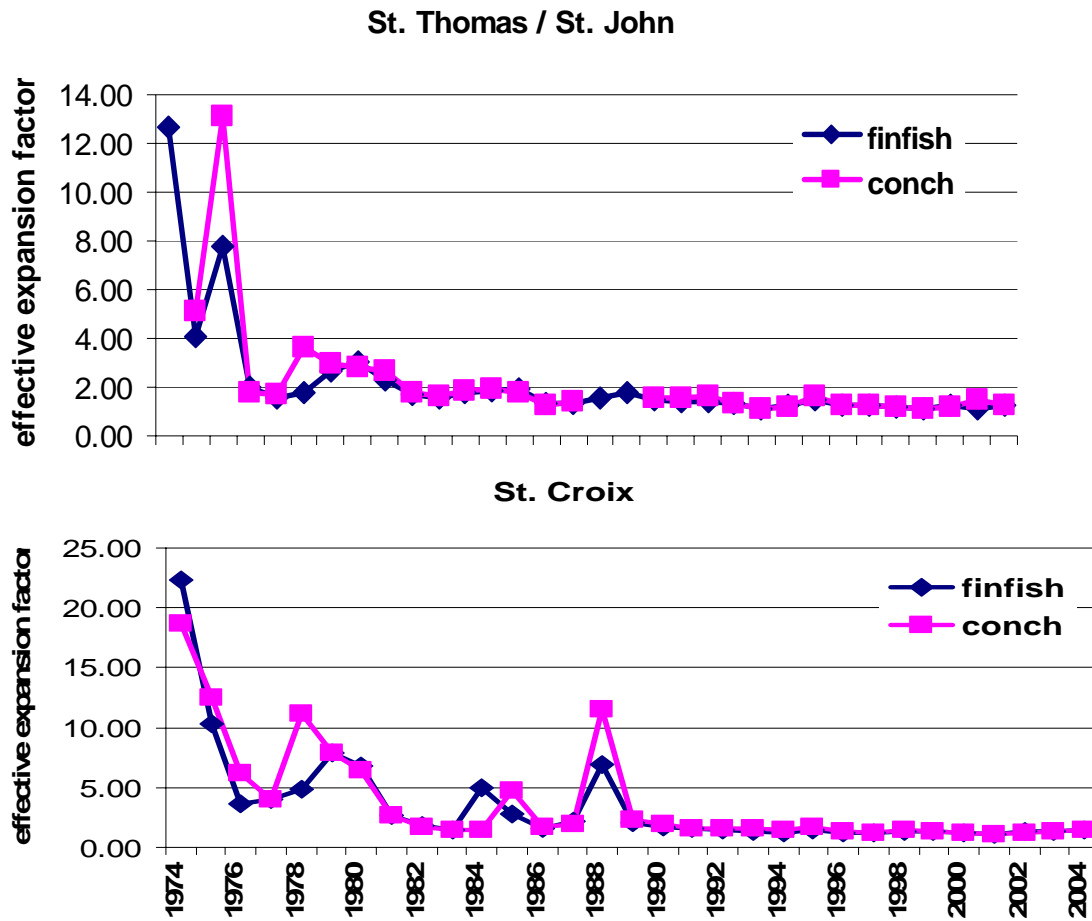


Figure 4. Effective expansion fractions for Virgin Island landings derived by dividing calculated total landings by reported landings.

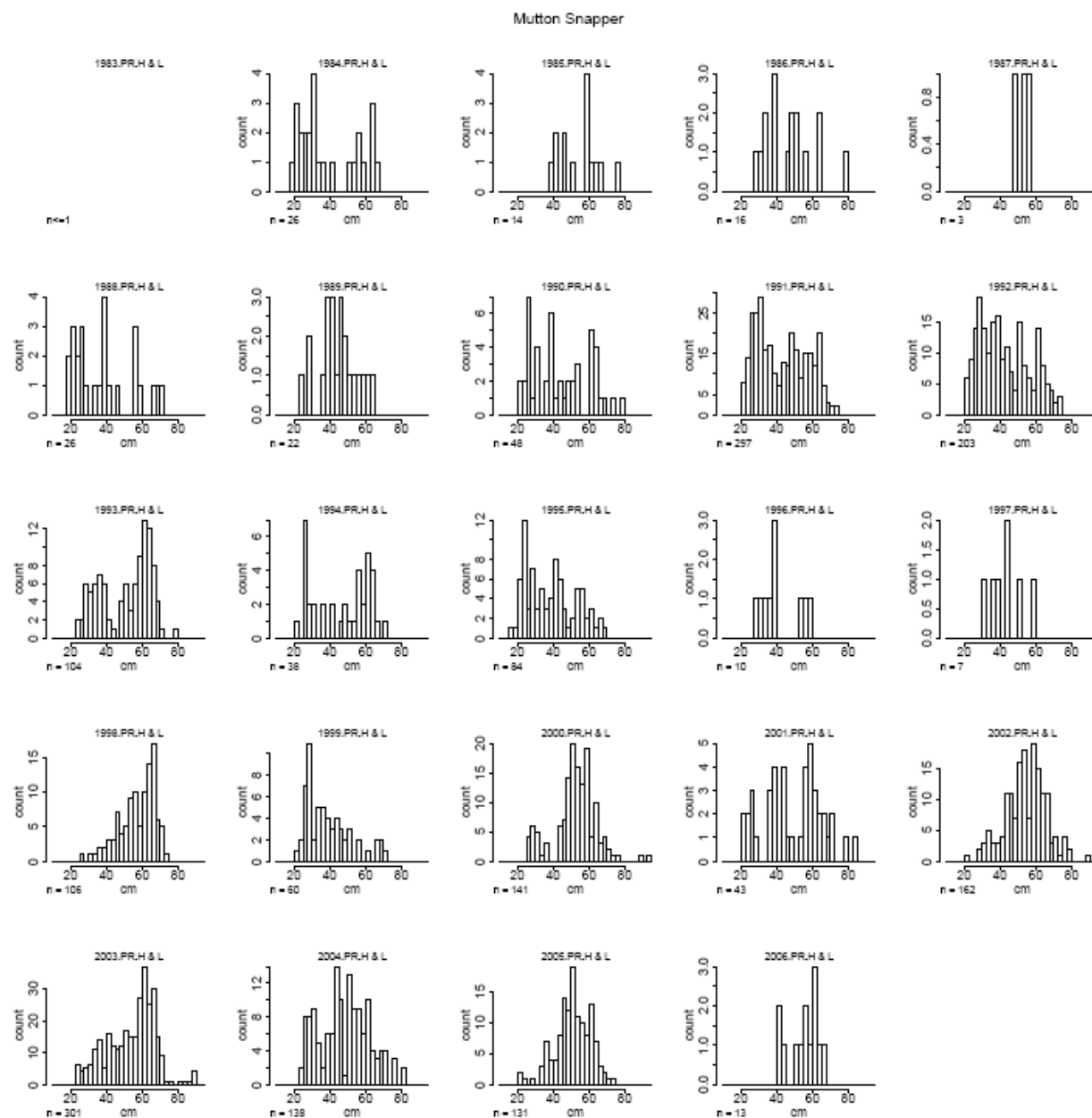


Figure 5. Number of mutton snapper at length (cm) from Puerto Rican landings by hook and line fisheries from 1983 through 2006. Note that the vertical axes vary in scale.

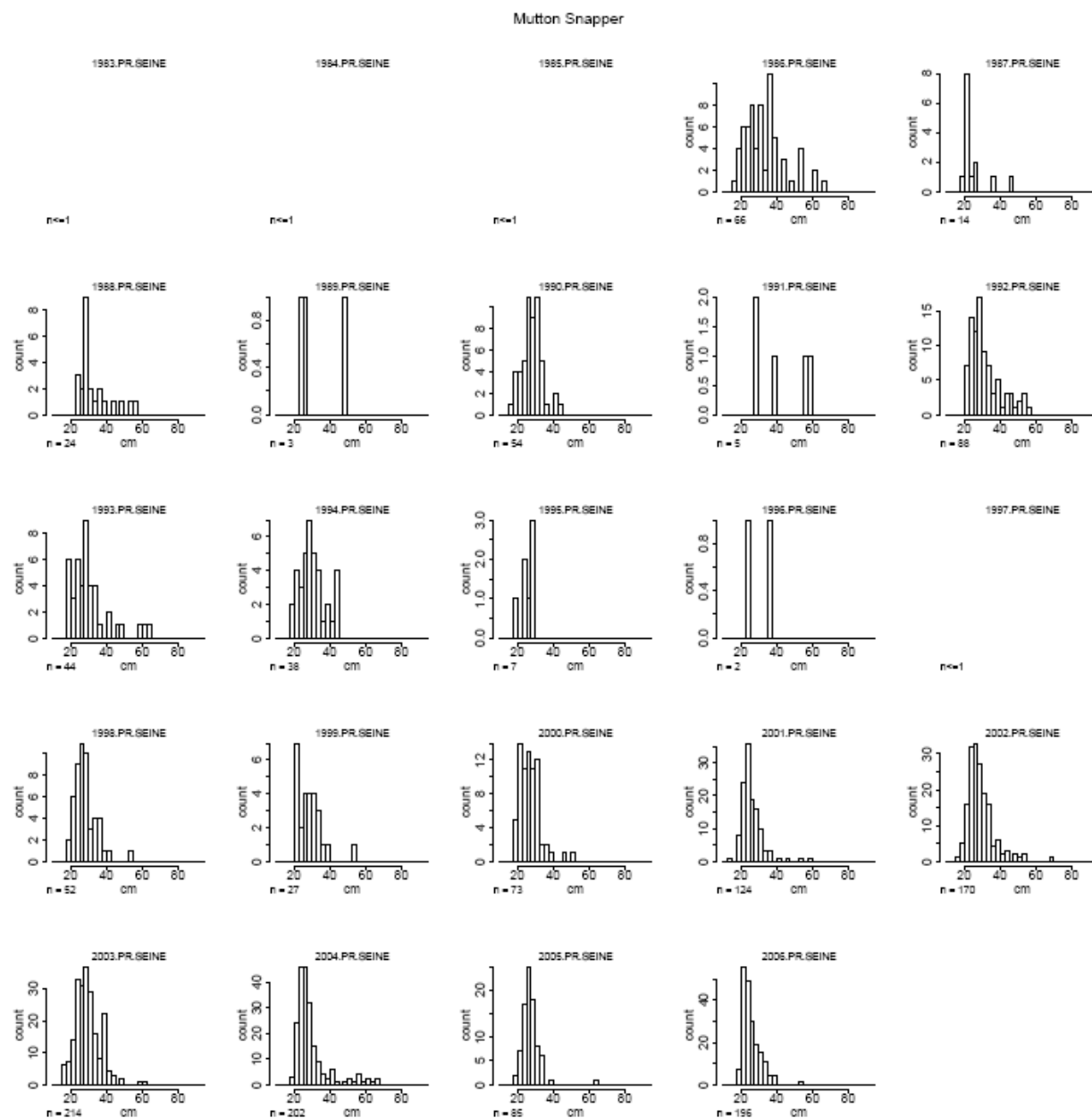


Figure 6. Number of mutton snapper at length (cm) from Puerto Rican landings by seine fisheries from 1983 through 2006. Note that the vertical axes vary in scale.



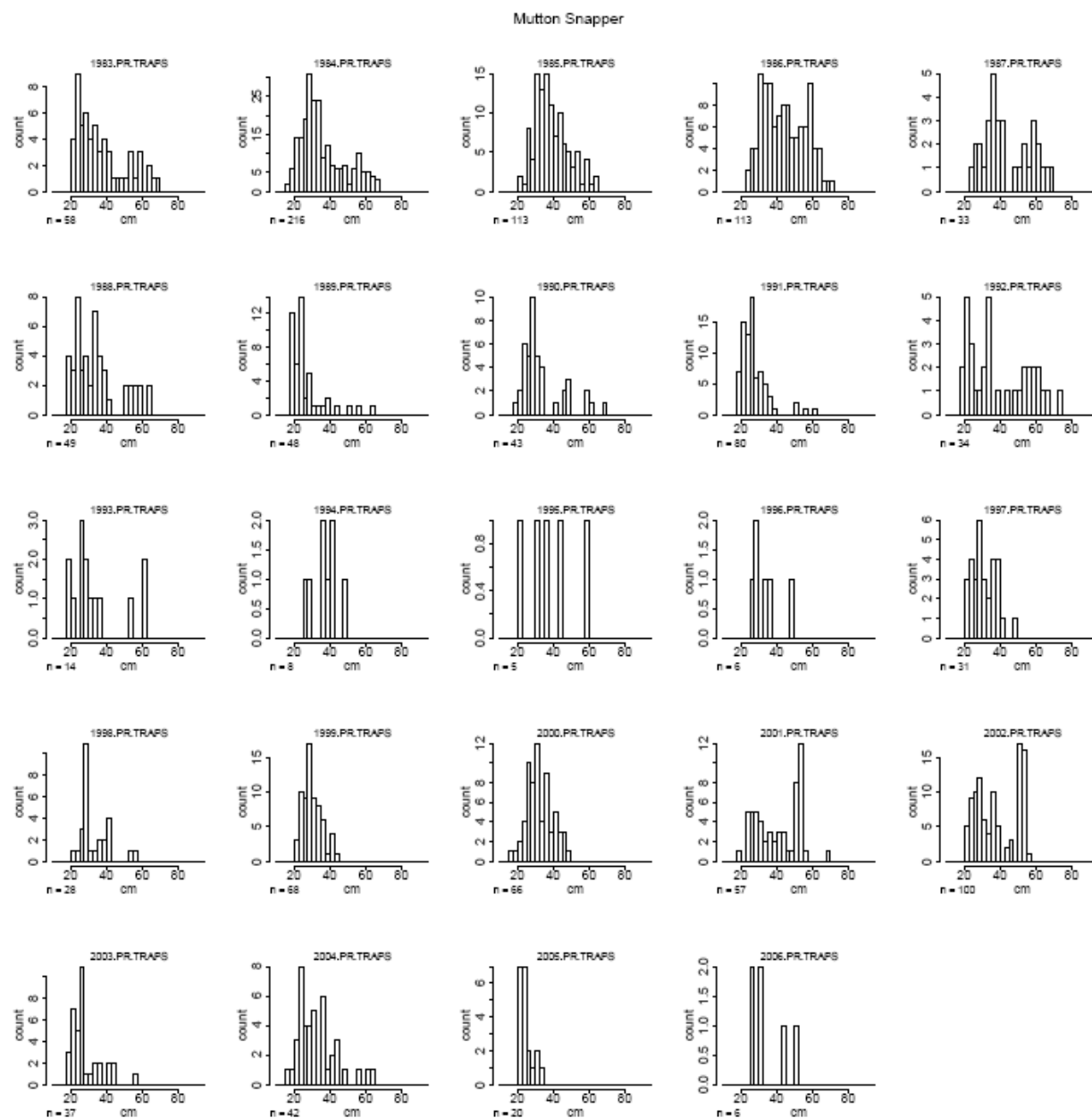


Figure 7. Number of mutton snapper at length (cm) from Puerto Rican landings by trap fisheries from 1983 through 2006. Note that the vertical axes vary in scale.

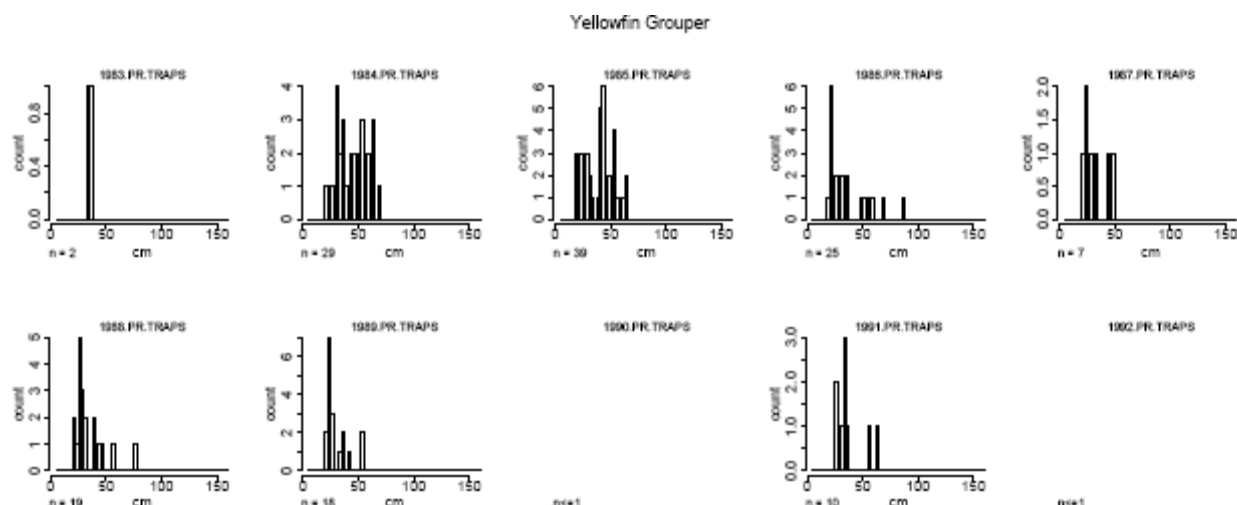


Figure 8. Number of yellowfin grouper at length (cm) from Puerto Rican landings by trap fisheries from 1983 through 1992. Note that the vertical axes vary in scale.

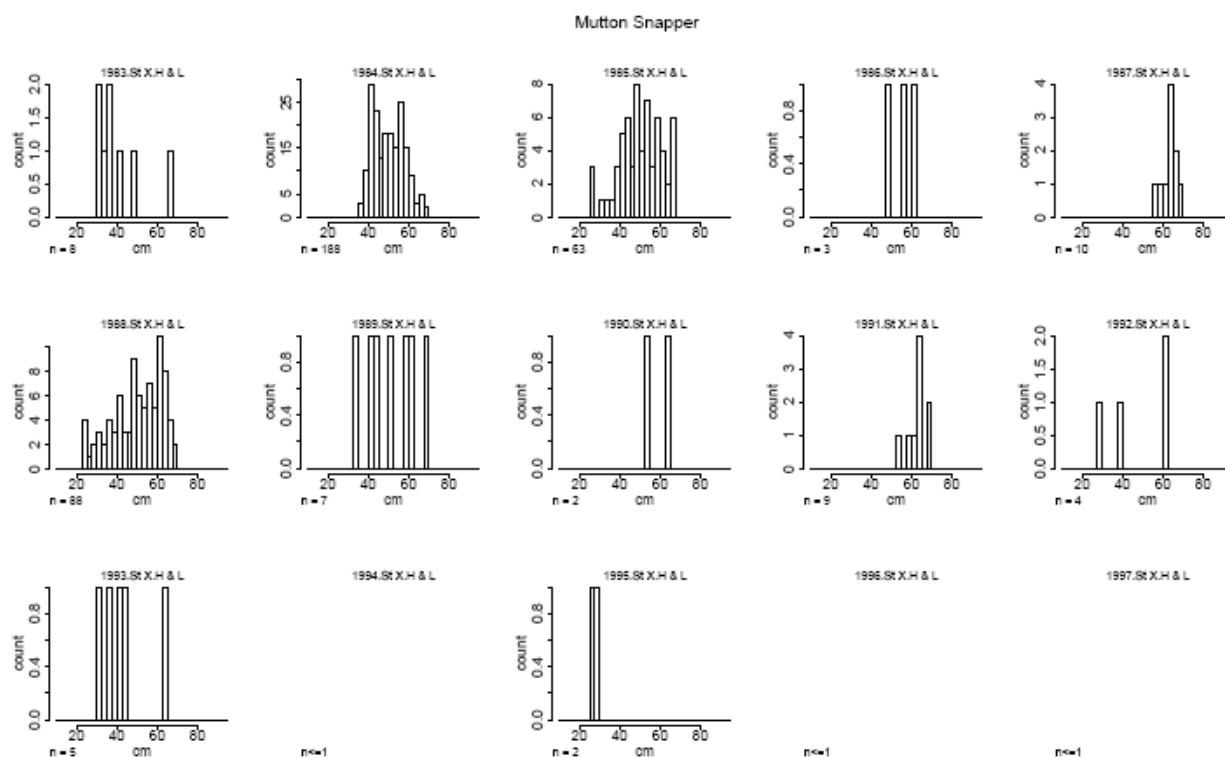


Figure 9. Number of mutton snapper at length (cm) from St. Croix (figures are mis-labeled) landings by hook and line fisheries from 1983 through 1995. Note that the vertical axes vary in scale.

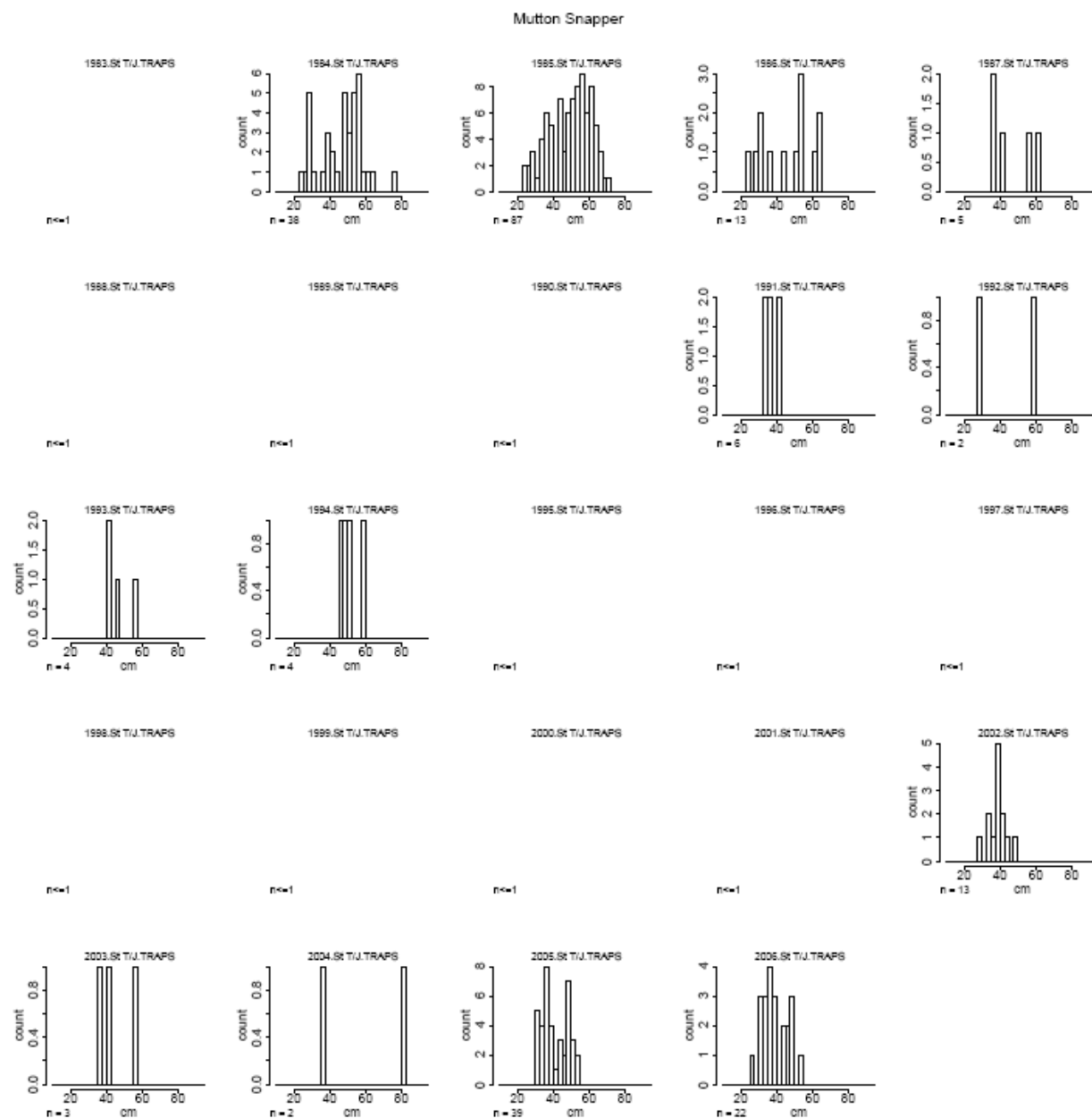


Figure 10. Number of mutton snapper at length (cm) from St. Thomas / St. John (figures are mis-labeled) landings by trap fisheries from 1984 through 2006. Note that the vertical axes vary in scale.

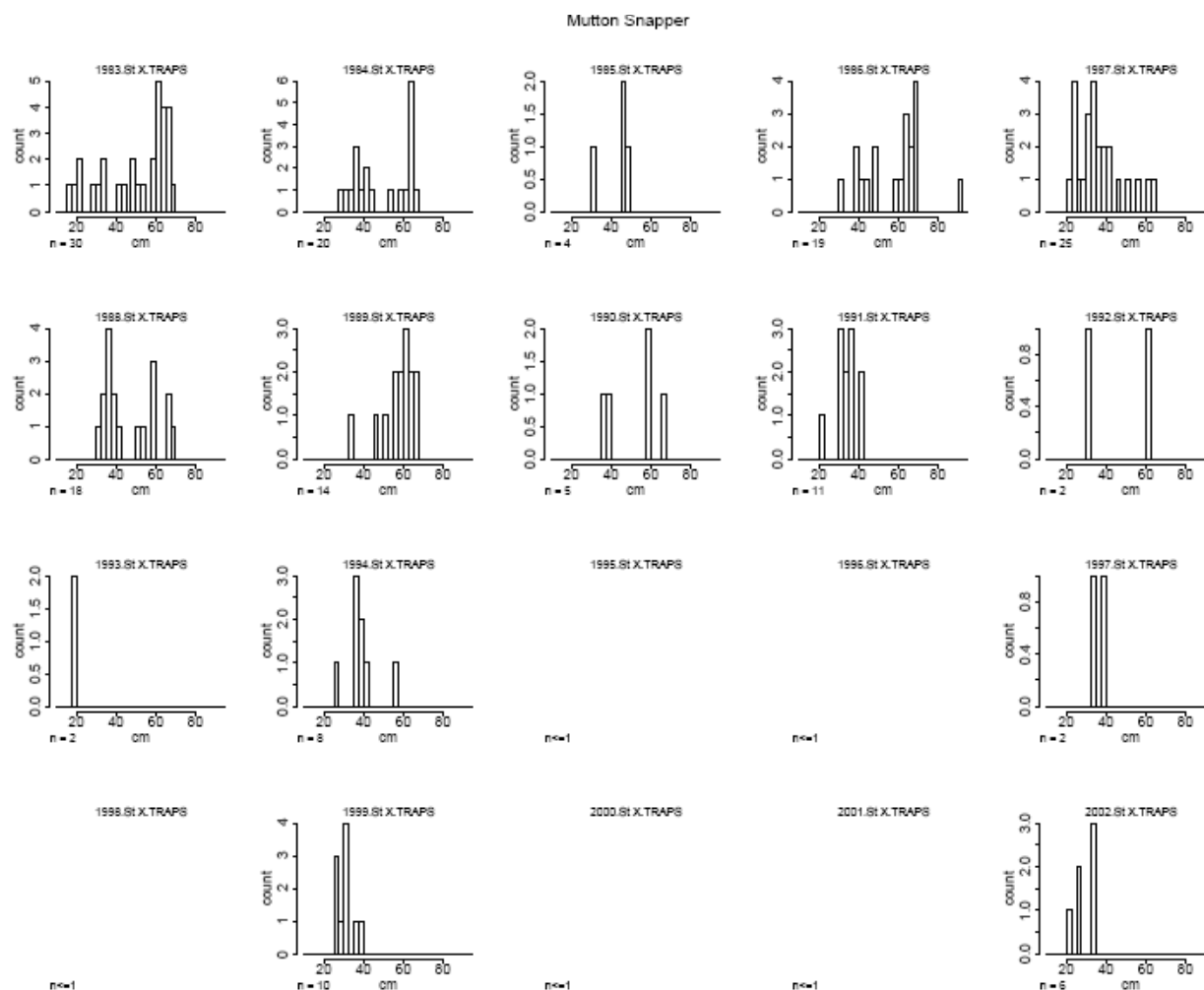


Figure 11. Number of mutton snapper at length (cm) from St. Croix (figures are mis-labeled) landings by trap fisheries from 1984 through 2002. Note that the vertical axes vary in scale.

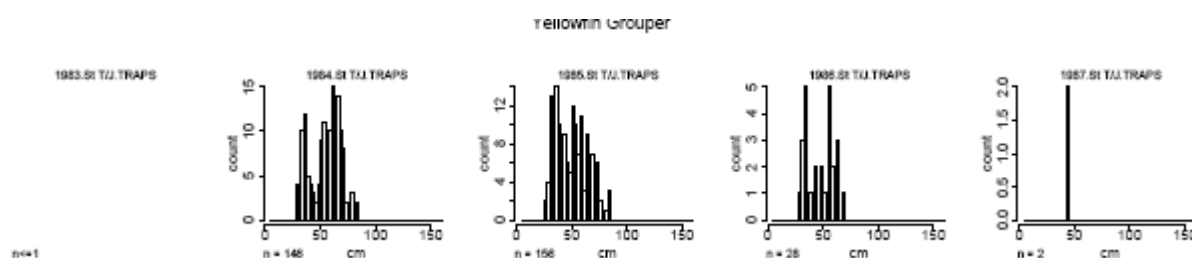


Figure 12. Number of yellowfin grouper at length (cm) from St. Thomas / St. John (figures are mis-labeled) landings by trap fisheries from 1984 through 1987. Note that the vertical axes vary in scale.

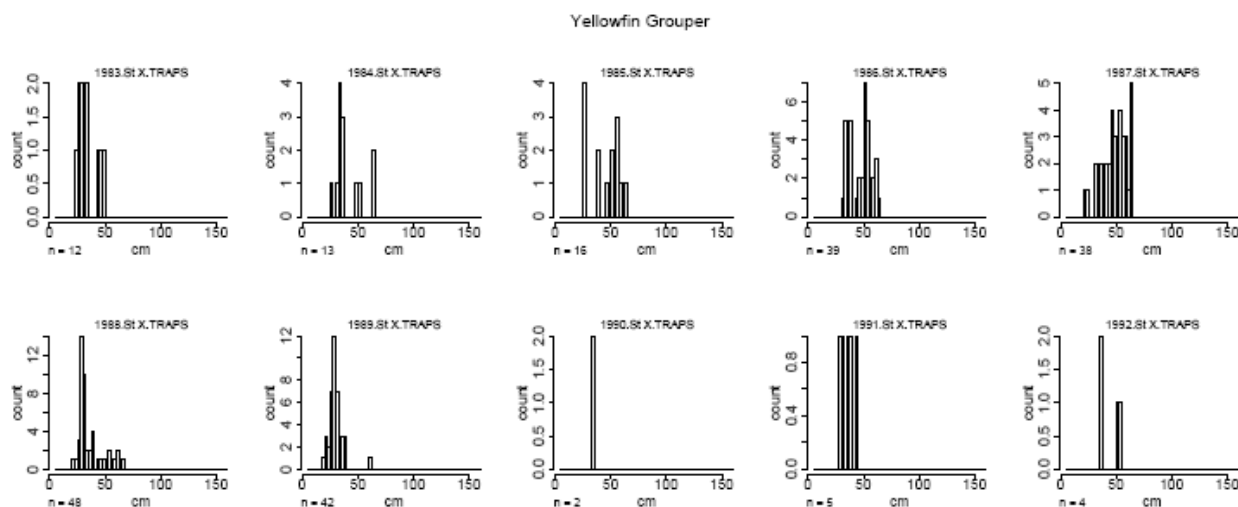


Figure 13. Number of yellowfin grouper at length (cm) from St. Croix landings by trap fisheries from 1983 through 1992. Note that the vertical axes vary in scale.

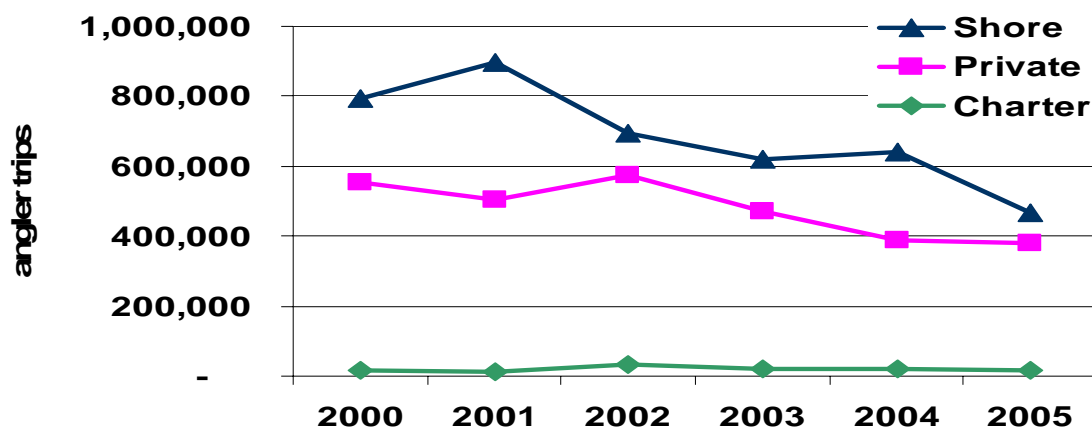


Figure 14. Estimated angler trips for Puerto Rico by mode from the Marine Recreational Fisheries Statistical Survey.

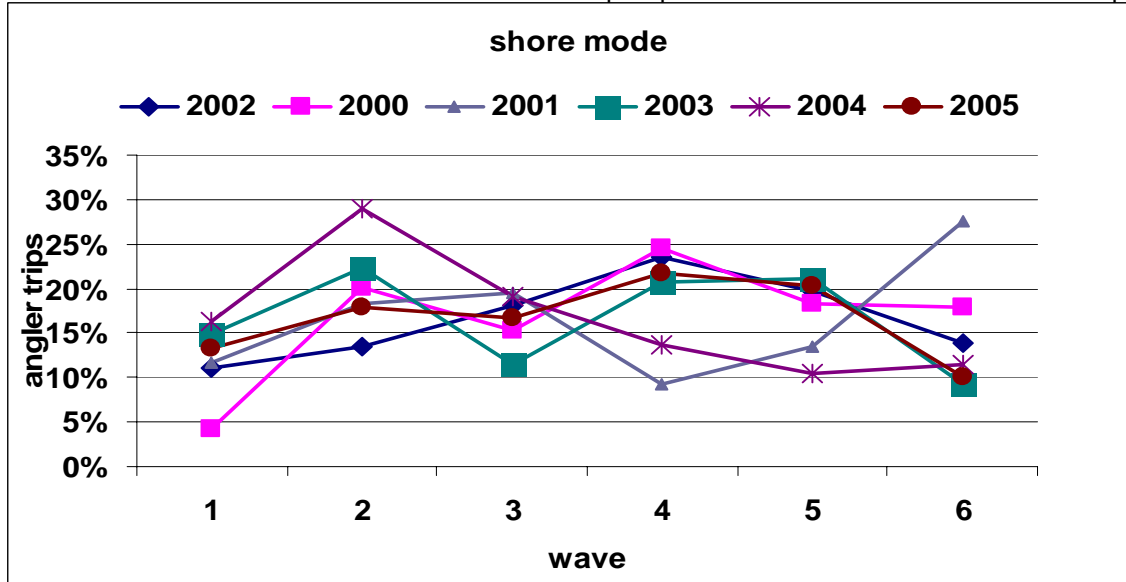


Figure 15. Percentages of estimated annual angler trips taken from the shore in each two month period (wave).

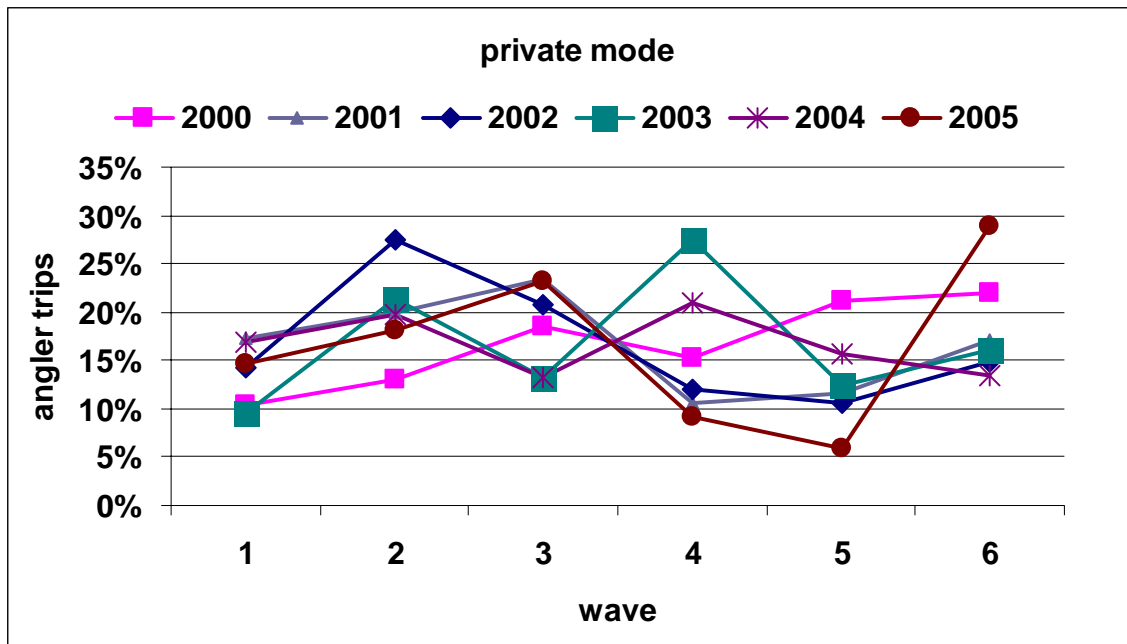


Figure 16. Percentages of estimated annual trips taken by private mode anglers in each two month period (wave).

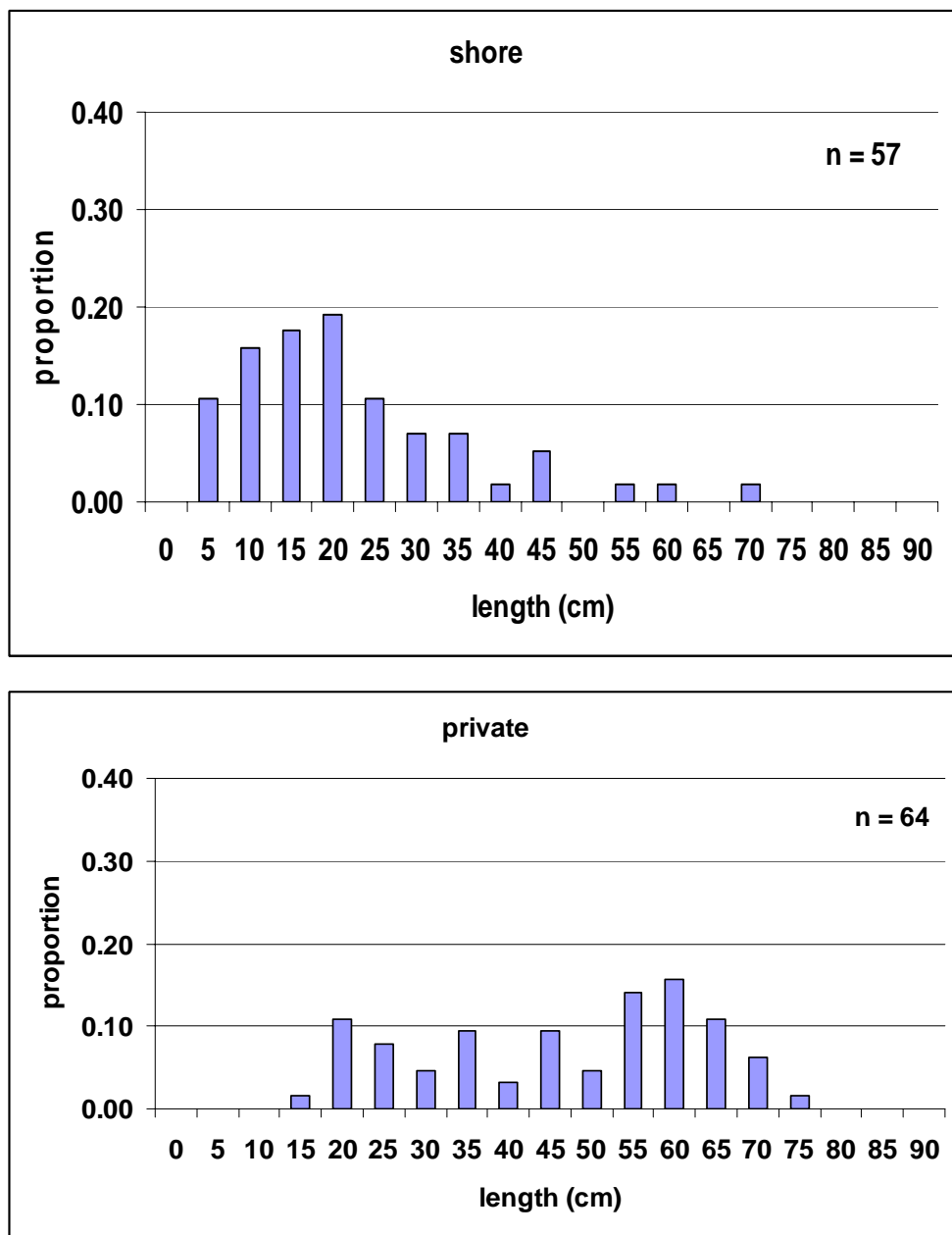


Figure 17. Length distributions of mutton snapper caught by recreational anglers in Puerto Rico fishing from shore or fishing from private or rental boats (private) during 2000-2005.

## 4. Recreational Fishery

### 4.1. Overview

Limited discussions of the recreational fisheries were held in the working group on catch statistics. Graciella Molinar-Garcia and Steve Turner led the discussions and wrote the reports. Primary information is provided in this section. A detailed overview of the recreational fishery in the U.S. Caribbean is included in Appendix 1. That document provides recent and historical information on the fishery management units, catches, effort, fishers, vessels and fleets

The recreational harvest of marine species in the US Caribbean is thought to be large, but until recently there have been very few surveys to document the recreational catch and effort. Apparently recreational effort is particularly high during holidays such as Easter week and summer vacations when large numbers of families camp along the shore and harvest fish and shellfish in near shore waters.

In the year 2000 the Marine Recreational Fisheries Statistical Survey (MRFSS) was initiated in Puerto Rico by the Department of Natural and Environmental Resources and by a private contractor in the U.S. Virgin Islands. The sampling efforts were unsuccessful in the Virgin Islands and were not continued in subsequent years in that area. Sampling in Puerto Rico has continued since 2000. The MRFSS collects catch information on finfish, but generally does not include invertebrates such as conch and lobster. However a special survey to record the number of participants in the recreational conch fishery was conducted by MRFSS in May through September of 2000; it estimated that there were 50,000 participants in the recreational fishery for conch in Puerto Rico and the Virgin Islands during that four month period.

### 4.2. Recreational Effort

The annual number of recreational angler trips in Puerto Rico as estimated by MRFSS declined from 2000 to 2005 for both shore and private mode fishing (Figure 14.). The number of trips by shore mode anglers declined about 40% from the 2000-2002 average and private mode (on private vessels and rental vessels) angler trips declined about 30%. In 2005 shore mode anglers took about 470,000 trips and private mode anglers took about 380,000 trips. In contrast the MRFSS survey estimated that the number of angler trips aboard charter boats ranged from about 10,000 trips to about 35,000 trips during 2000-2005.

In Puerto Rico and the U.S Virgin Islands recreational fishing activity by residents is thought to be high during Easter week (when fish consumption increases) and during summer holidays. The MRFSS estimates of shore mode indicates increases in the percentage of angler trips in both shore and private mode from January-February (wave 1) to March-April (Figures 15 and 16). In most years a greater percentage of the annual effort occurred in March-April than in May-June and the March-April effort often represented a similar percentage as in June-July and August-September.

The MRFSS estimated that there were about 55,000 angler trips in the St. Thomas in 2000 compared to more than 1.4 million angler trips in Puerto Rico that same year; about 85% of the estimated angler trips in St. Thomas were by private mode anglers and the remainder was by



shore mode anglers. The reliability of the MRFSS estimates for St. Thomas is uncertain due to the difficulties in executing the survey.

#### 4.2.1. Recreational Catch (landings and discards)

SEDAR14 DW03 reported that the MRFSS estimates of the number of mutton snapper killed each year ranged from about 6,000 to about 25,000 and the number released alive ranged from less than 1,000 to about 6,500 each year (Matter 2007). In most years no yellowfin grouper were observed caught by anglers interviewed in the MRFSS field surveys; in the two years when yellowfin grouper were observed the estimated total kill was less than 1,000 fish and none were reported released alive. The calculated coefficients of variation about the estimated kill in Puerto Rico ranged from about 30% to 50% for mutton snapper in private and shore modes, though it is likely that the true uncertainty is higher.

#### 4.2.2. Biological Sampling

There were 111 mutton snapper measured in the MRFSS survey in Puerto Rico in 2000-2005. Roughly 80% of the mutton snapper caught by shore mode were less than 30 cm, while about 75% of the mutton snapper caught by private mode anglers were 30 cm or greater (Figure 17).

There were 5 yellowfin grouper measured in the MRFSS survey in Puerto Rico in 2001 and 2003. Those fish ranged from about 60 cm to about 85 cm (Matter 2007).

#### 4.2.3. Sampling Intensity

The MRFSS survey in Puerto Rico observed roughly 0.1% to 0.25% of the estimated total landings of mutton snapper (Matter 2007). However when mutton snapper were observed, nearly all were measured.

#### 4.2.4. Length – Age distributions

Length and age distributions of the catches were not estimated.

#### 4.2.5. Adequacy for characterizing catch

The MRFSS may provide useful information on the magnitude of the recreational landings of mutton snapper taken in the shore and private mode fisheries in Puerto Rico. However the time series is short which is likely to present problems for conventional stock assessment methods.

The MRFSS estimates of the recreational landings of yellowfin grouper in Puerto Rico indicate that the landings are quite low.

The exclusion of conch from the MRFSS is problematic for conducting stock assessments of that species, because the recreational harvest is thought to be large.

The absence of multi-year estimates of the magnitude of species specific catches of finfish in the Virgin Islands for both the recreational and commercial fisheries will be problematic conventional stock assessments for mutton snapper and yellowfin grouper.

The absence of estimates of recreational landings of queen conch may not be problematic for St Thomas / St. John because the landings are thought to be low. However the recreational landings of conch in the St. Croix and Puerto Rico are thought to be relatively large and thus the absence of recreational landings estimates would likely be problematic for conventional stock assessments of those resources.

#### 4.3. Research Recommendations

Conduct surveys to estimate the magnitude of the U. S. Virgin Islands recreational landings for all species including conch and lobster. It is possible that using a Virgin Islands contractor would improve the likelihood of success of the survey.

Include conch and lobster in the MRFSS for Puerto Rico.

To adequately characterize catch rates and sizes of mutton snapper caught by recreational anglers in Puerto Rico, very substantial increases in dockside sampling will be needed

#### 4.4. Recreational Fishing in Puerto Rico and the USVI

SEDAR 14

(Yellowfin grouper, mutton snapper, and queen conch)

Graciela Garcia Moliner, Vivian M. Matter, Wes Toller, W. Tobias and Steve Turner

##### 4.4.1. Preface

There is no monitoring of the recreational fishing sector in the US Caribbean other than MRFSS in Puerto Rico. The samples from the MRFSS for yellowfin grouper between 2000 and 2006 are 4; 111 for mutton snapper and none for queen conch. Although the harvest by recreational fishers is believed to be significant, other than MRFSS estimates there are no hard data to estimate this catch.

Local knowledge indicates that the harvest of juvenile fish during camping trips to the shore line (e.g., Eastern week, summer vacations, etc.) could be potentially very high but there is no documentation of these events.

##### 4.4.2. Definition of FMU

The 2005 SFA Amendments to the FMPs redefine FMUs in the Queen Conch and Reef Fish FMP. The FMU in the QC FMP include primarily *Strombus gigas*, the indicator species for a group that includes the smaller conchs (*S. pugilis*, *S. gallus*, *S. raninus*, *S. costatus*) and *Charonia variegata*, *Cassis madagascarensis*, *Fasciolaria tulipa*, and *Astrea tuber*. The greatest part of the catch is *S. gigas* (A. Maldonado, PR Conch Fisher) and there is very little landing by conch fishers of other species.

The RF FMP FMUs were grouped in units corresponding to similar biological parameters, fishing depth, and occurrence in the multi species landings. The mutton snapper (*Lutjanus analis*) is in Snapper Unit 3 which includes *L. synagris*, *L. jocu*, *L. apodus*, *L. griseus*, and *L. mahogany*. The mutton snapper and lane snapper show the highest landings of the unit and mutton snapper is the indicator species on the unit.

The yellowfin grouper (*Mycteroperca venenosa*) is the indicator species within Grouper Unit 4 which includes *M. bonacci*, *M. tigris*, *E. flavolimbatus*, and *E. morio*.

#### 4.4.3. Background Information

The Comprehensive SFA Amendment (2005) includes some of the information available from the recreational harvest but no sector of the recreational/charter fishery has ever been required to surrender landings data nor have these sectors been monitored as regularly as the commercial sector. The reports and studies on the biology of the species including size distributions, length at maturity, age and growth, etc. have seldom if ever included samples from the recreational/ charter harvest with the exception perhaps of HMS.

The SFA document also identified the gaps in the information. One of the largest gaps in information identified was the scarcity of recreational (private, charter, shoreline, divers) data, especially total harvest, catch and effort, and biological parameters of the species such as weights, gear used, areas fished, etc. for the species harvested recreationally.

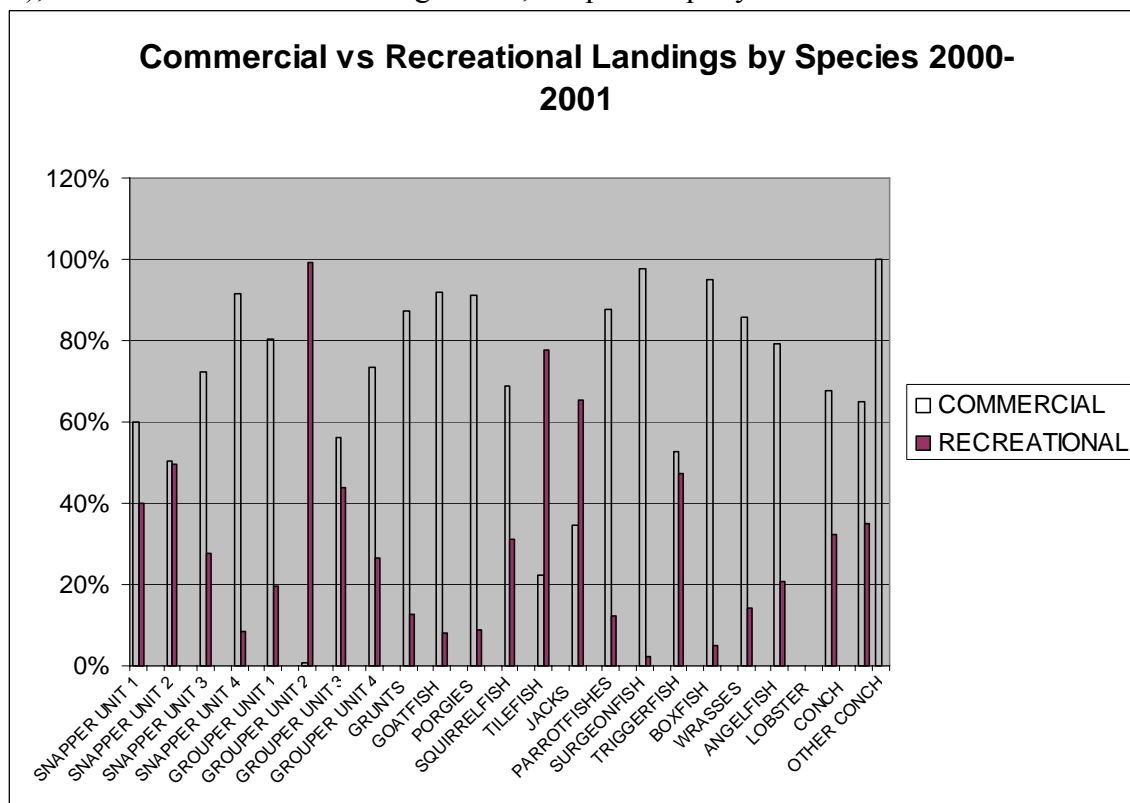
#### 4.4.4. Recreational Catch

##### 4.4.4.1. Puerto Rico

MRFSS was expanded to Puerto Rico at the end of 1999. Data from this survey indicate that total recreational landings in Puerto Rico were 2.8 million lbs and 1.7 million lbs in 2000 and 2001, respectively. Recreational fishermen landed, on average, 1.03 million lbs of Council-managed species, annually, in Puerto Rico during that time period (see Appendix 1; Tables 6 and 7 of the SFA Amendment (2005)). The MRFSS does not collect data on USVI fisheries. Table 6 of the SFA (2005) explains how data on the recreational fishery of Puerto Rico were extrapolated to estimate average, annual, recreational landings in USVI fisheries of 303,069 lbs. Total average annual recreational landings for Puerto Rico and the USVI combined are estimated at 1.3 million lbs. This estimate is only for the reef fish managed by the CFMC. Dolphin fish alone accounts for over 1,000,000 pounds landed per year by the recreational sector. The MRFSS does not collect data on the invertebrates and the estimated landings from the recreational catch are from a survey during 2000 conducted for a period of 3 months in Puerto Rico.

Total recreational finfish catch (i.e., of Council-managed species) for Puerto Rico was 43.77% of commercial finfish landings. For Puerto Rico, the majority of catch occurred in state waters. However, deep water snappers are reported by recreational fishers as much as they are reported by commercial fishers. Most of the fishing for deep water snappers takes place in federal waters. "Other Fishes" (not identified in the MRFSS data set) and snappers make up the majority of the recreational landings in state waters. Dolphin and tuna dominated the recreational catch in the EEZ. Recreational landings of spiny lobster in Puerto Rico reached 128,560 lbs in 2000 and 142,707 lbs in 2001. Recreational landings of queen conch in Puerto Rico are estimated at 140,157 lbs in 2000 and 124,085 lbs in 2001. There is apparently a significant number of fish that are released because (1) they might be ciguatoxic, (2) the charters do not allow fishers to keep most of the catch, (3) fishers are just fishing for fun and/or relaxation. However, this deserves further investigation since in some cases the release of certain edible species is 100%.

The MRFSS included an add-on to survey participants in the queen conch fishery for waves 3 and 4 in 2001. The number of participants was estimated at over 50,000 for Puerto Rico and the USVI. If these 50,000 harvest the recreational bag limit (3 conch or 1 pound of conch per fisher), the total harvest can be as high as 50,000 pounds per year.

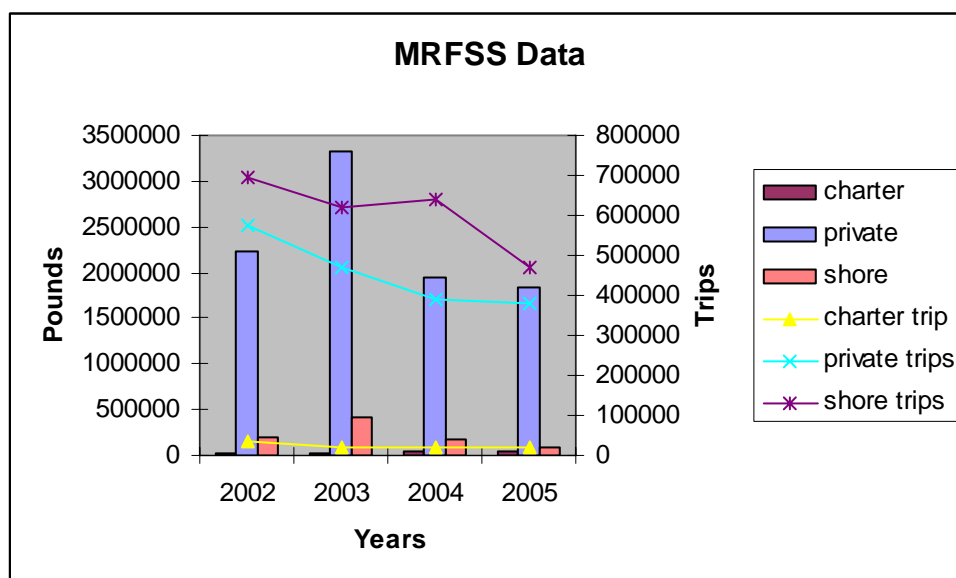


The figure above, that needs to be updated, shows the distribution of harvest by recreational and commercial fishers in the US Caribbean. The recreational fisheries include Goliath grouper (99% recreational), tilefish (78%), jacks (65%), queen snapper (50%), silk snapper (40%) queen conch (35%) and spiny lobster (35%). The overlap in species harvested of commercial value is significant. It is not known if there is a surplus of the species harvested in the reef fish category and thus there is a need to assess the data. In 2000, there were 2,786 field intercepts from MRFSS. In 2001, there were 222,128 recreational fishers in Puerto Rico (MRFSS). The information on the landings by species and mode, including the number of fishers involved in the fisheries has been requested from MRFSS. The data available on size distribution of yellowfin grouper and mutton snapper from 2000 to 2006 show a total of 5 yellowfin and 111 mutton. No samples for queen conch are available.

Appeldoorn and Valdés-Pizzini (1996) conducted a three-month survey targeting Puerto Rican recreational boat users who trailered their boats. A total of 312 boats were surveyed; 41 reported fishing and four of these reported fishing for queen conch while snorkeling. They also sampled finfish during the survey and showed that many of the fishes harvested by the recreational sector were juveniles. They also reported that, aside from clupeids taken for use as bait, the most caught species were silk snapper, red hind, and lane snapper. Most trips targeted

groupers and snappers. This corroborates the available MRFSS data for Puerto Rico, which indicates that silk snapper, lane snapper, queen snapper, black durgelon, and red hind were the predominant recreational species. Jacks also were a major recreational target, but were not identified by individual species.

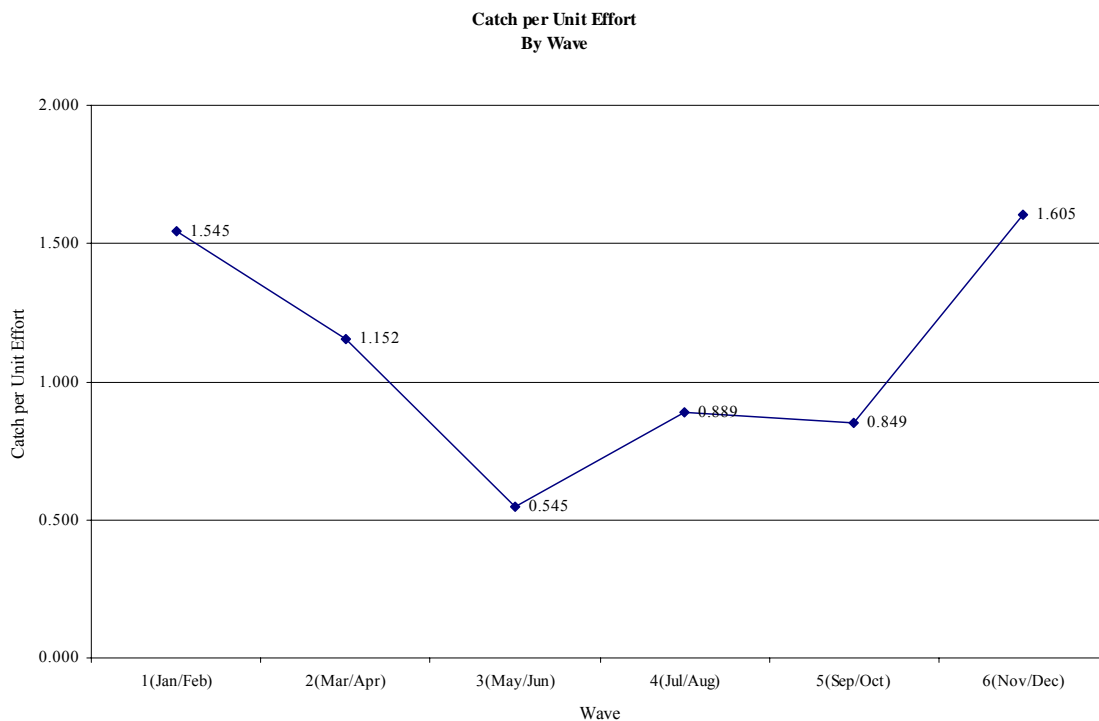
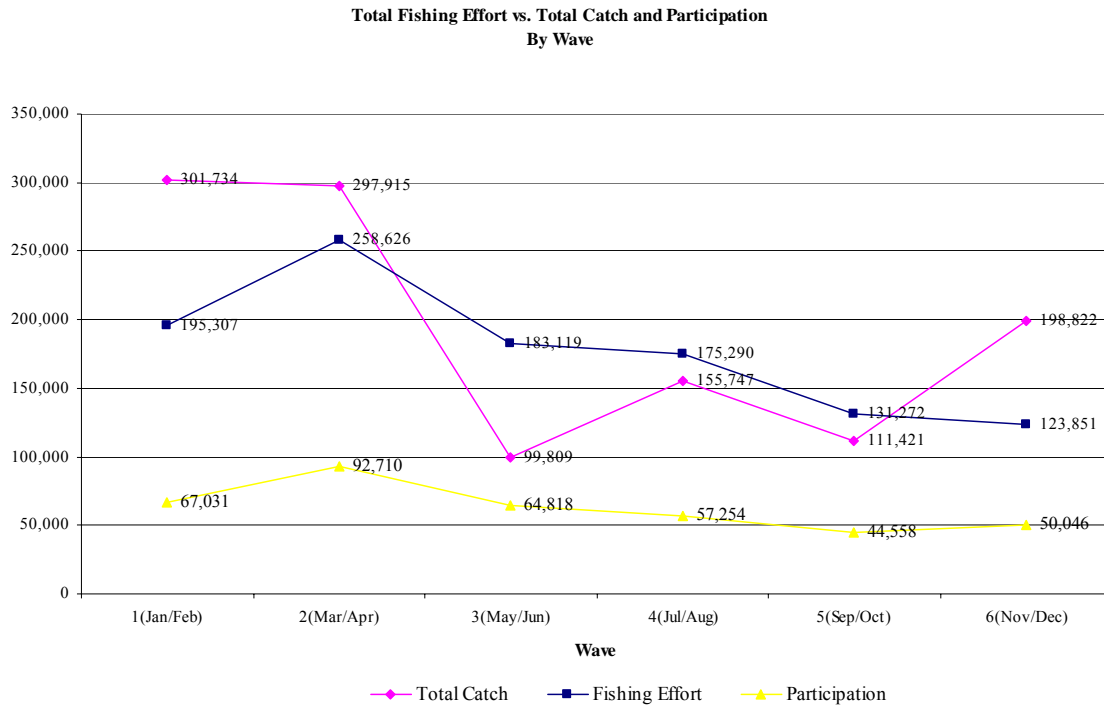
The MRFSS query showed that most of the harvest of dolphin, tunas and mackerels and barracuda is from the EEZ; some groupers and snappers (including yellowfin grouper (n=2 out of 5) and mutton snapper (n=12 out of 111) are reported from the area beyond the 10 mile territorial limit for the years 2001-2005. The size distribution of the mutton snapper indicates that 56 are under the minimum size at maturity for females (Figuerola and Torres) determined from the commercial catch and 55 are over the minimum size.



The figure shows the decrease in the number of trips taken from 2002 to 2005 for each of the fishing modes reported to MRFSS (lines) as well as the changes in the catch. At this time there is no further breakdown of species being landed for each year beyond the general categories of dolphin fish, tunas, mackerels and groupers, etc. The data have been requested from the NMFS. Dolphin fish and tunas account for about 50% of the totals reported. Landings estimates range from a low of 2 million pounds to 3.5 million pounds in 2003. It is not known if the survey effort has decreased or if the number of participants has decreased.

(DRNA PR 2005) reported for 2004 that shoreline trips accounted for 60% of the recreational/charter fishing trips with private/rental trips accounting for 38% and charter trips 2.1%. The seasonality of the trips varies for each mode but the period January through April appears significantly different from the rest of the year for all modes; highest number of trips was recorded during March-April (Holy Week, a religious period when fish consumption increases) as well as highest catch. Fishing effort being highest in the March-April months does not coincide with highest CPUE. Highest CPUE was reported during November-December. Highest number of charter trips was reported during January-February and November-December. The number of charter increases during the high, non-local tourist season. Private/rental boats

showed increased number of trips during March-April and July-August (summer vacation and local-Caribbean wide high tourist season).



(CLAPP AND MAYNE, INC. 1979) indicated the most common used gear by recreational fishers was hook and line (62% casting/fishing rod) and 43% bottom fishing) with a

proportion corresponding to 98% of the respondents using this gear (85% of the commercial fishers used this gear). The other most common gear was speargun (28%) for recreational fishers (commercial fishers with 25%). Less than 27% of the respondents used nets or traps when recreationally fishing (over 50% of the commercial fishers reported using traps and nets). The MRFSS database needs to be assessed for the use of other gears by recreational fishers in Puerto Rico.

#### 4.4.4.2. USVI

There are no on-going projects in the USVI to collect recreational data from the reef fish or queen conch fishery. One project collected information from the logbooks voluntarily filled out by offshore recreational fishermen, and the second project collected information from nearshore recreational fishermen. Both projects ended in 2001. The offshore fishermen target primarily blue marlin, dolphin fish and wahoo. Of 563 recreational nearshore anglers interviewed in the USVI between 1995 and 1998, fishermen most frequently reported catch of French grunts, jacks, and yellowtail snappers (I. Mateo, USVI/DPNR). The reports available from the USVI describe the recreational shoreline, pier, tournament and offshore private boat fishing activity. There is no detailed information on the charter fleets of the USVI. The offshore marlin fleet was monitored (e.g., Brandon 1989, Friedlander 1995) since the area has been described as one of the most productive marlin grounds in the Caribbean. There are no yellowfin grouper reported from the recreational sector in the USVI (W. Toller and T. Tobias); mutton snapper were sampled from the shoreline fishers. The data need to be revised. (TO DO)

Other surveys reported on non-charter recreational activity (JENNINGS 1992), marine recreation services (HINKEY-MACDONALD; QUINN and others 1994) and socio-economics of recreational boating and fishing ((OLSEN 1979) but all with very limited information on the charter operations and with limited sampled data on recreationally caught fish. One report estimated a charter fleet of about 150 for St. Thomas, with over 40 of these vessels coming from the US mainland during the marlin season, and about 30 charter operations in St. Croix.

The first quantitative report on the shoreline recreational fishery of St. Croix shows that two (out of a total of 48 species reported) of the most frequently caught fishes (mojarras and anchovies) were primarily used as bait for barracuda and yellowtail snapper (Adams 1997). It also suggests that the shoreline fishery is declining, with CPUE declining since 1995, with increased effort every year. Among the species landed were red hind, yellowtail snapper, and seven other species of snappers, grunts, etc. These were caught using hook and line and nets (Adams 1995).

(Mateo; R. Gomez; K. Roger Uwate; B. Kojis, and D.C. Plaskett 2000) offers the most complete information on the limited sampling that was done between 1995 and 2000 of the recreational survey in St. Thomas and St. Croix. The species reported during shoreline tournaments (limited to Mother's Day tournament in St. Thomas offer a limited glimpse at the species caught (fate unknown) of very small reef fish (the heaviest fish was a trunkfish weighing 3.42 pounds).

Jennings (1992), from a telephone survey conducted in 1986, estimated fish harvest by recreational fishermen in the USVI at 24,648 kg-fish annually (54,226 lbs. /year). The most frequently reported species were yellowtail snapper and red hind, in addition to mackerels and

tunas reported specifically from St. Croix. In the mid-1980s, 10% of the residents of the USVI fished recreationally. Jennings (1992) indicates that the proportion of anglers fishing from the shoreline in St. Croix was higher than in St. Thomas/St. John. Bottom fishing and trolling from recreational vessels were the most frequent fishing activities targeting reef fish and were most common in St. Thomas.

(OLSEN 1979) estimated the recreational (based on a 12% response rate) landings at about 448,600 pounds annually. Furthermore, for reef fish (over 105,000 pounds annually) combined with the commercial catch of 1.6 million pounds annually was so close to the estimated MSY (Kumpf 1978) that “It is clear that the user groups are approaching a situation where allocation may be required (page 16).” {The SFA (2005) estimate for the recreational catch in the US Caribbean was estimated at about 1 million pounds compared to the commercial catch of 2.2 million pounds.}

In 1978 there were 1,789 registered boats in the USVI. The definition of recreational fisherman was at the time all inclusive “ is part of a population which may range from resource users that haul up to 100 traps three days a week to the snorkeler who may use the resource once ... a month”. The work of Olsen has not been repeated in the USVI and the information contained therein needs to be updated. The report includes information on the household income, boat characteristics (HP Length, etc.) fishing gear and the general information on age, ethnicity, education as well as the expenditures and costs associated to recreational fishing. In 1978-1979, less than 2% of the fleet carried passengers for hire. The charter fleet was not adequately sampled but it was estimated at 200 to 300 vessels employed in the charter business.

Harvesting preferences at the time (OLSEN 1979) included lobster diving, spearfishing and diving for conch; in terms of effort the dolphin and the snappers and groupers were most frequently sought. Trap fishing was also included in the results but appears to be from commercial fishers rather than recreational as the estimated landings are over 1 million pounds.

#### 4.4.5. Social and Economic Information

In 1988, the marine recreational fishing activities needed little development in the USVI ((GRIFFITH; JOHNSON and others 1988)), while more effort was needed in Puerto Rico in support of recreational fisheries. The pilot work of the MRFSS and the socio-economic survey indicated that commercial fishers were already partaking on the development of a recreational fishery on the Island. In 1988, there were 4 charters in Puerto Rico and 4 in St. Thomas that were identified and the recommendation was to support the expansion of this fleet. At the same time it was recommended that the recreational fishing sector be monitored and data be collected to manage the fleet.

There are few studies after the 1980's collection of papers and virtually no monitoring of the recreational fishing activity until 2000 in Puerto Rico and 2002 in the USVI. The (H. JOHN HEINZ III CENTER ) report includes a brief discussion on the lack of information on the recreational sector, the need for data collection and the management burden carried by the commercial fishers in the US Caribbean.



#### 4.4.6. Fishers

Presently, Puerto Rican recreational fishermen 13 years and older (excluding those fishing off charter or head boats) are required to have a license. Information on the recreational fleet, charter fleet, and fishing enterprises other than the licensed commercial fleet is scant. Queries run on the NOAA Fisheries MRFSS dataset indicate that Puerto Rico had 222,128 recreational fishermen in 2001, and 28,757 of these were from out-of-state. In contrast, Schmied (1989) reported only 81,000 resident marine recreational fishermen (from about 23,000 boats) for Puerto Rico. A creel census of 132 recreational shoreline anglers and 20 boat-based anglers was conducted in the area of Guanica State Forest between October 1997 and September 1998 (Silva et al. no date). The age of anglers was not dominated by any one group, but the 41-50 year old group (24.4%) was the most common. Shoreline-based angler effort was highest in August, June, and October; and lowest in January and March. Recreational anglers in Puerto Rico made approximately 1.4 million fishing trips in 2001 (NMFS 2002), of which 0.9 million were from shore, 0.5 million were from private boat, and 11,000 were from charter boat. This work needs to be revised for species sampled.

A telephone survey of a subset of USVI registered boat owners (n=120) who used their vessels for recreational fishing was conducted in 2000 (Eastern Caribbean Center 2002). Based on that survey the number of boat-based recreational fishermen was estimated at 2,509 for the USVI (712 from St Croix and 1,797 from St. Thomas/St. John). These fishermen were predominantly male (96.7%), with a mean age of 47.5 years old, and were of various ethnic heritages, education levels, and income levels. The number of recreational fishermen in the USVI (boat-based and shore-based fishermen) was estimated to be around 11,000 people in 1999, about 9.2% of the population, which is roughly the same proportion that Jennings (1992) found in 1986 (see Mateo 1999; Eastern Caribbean Center 2002). A survey of 312 boats taken at boat ramps stated that only 41 vessels (13%) reported fishing as one of their activities (Appeldoorn and Valdés-Pizzini 1996). Of these 41 vessels, 80% used hook and line/rod and reel gears.

A total of 814 recreational anglers were counted on St. Croix, of which 404 were interviewed (Eastern Caribbean Center 2002). The highest fishing effort took place in the afternoon hours and during the months of May through July. Most of the fishing areas however are nursery grounds where juveniles of species occur. The USVI Division of Fish and Wildlife, Department of Planning and Natural Resources (DPNR) is currently assessing the recreational fishery of the USVI.

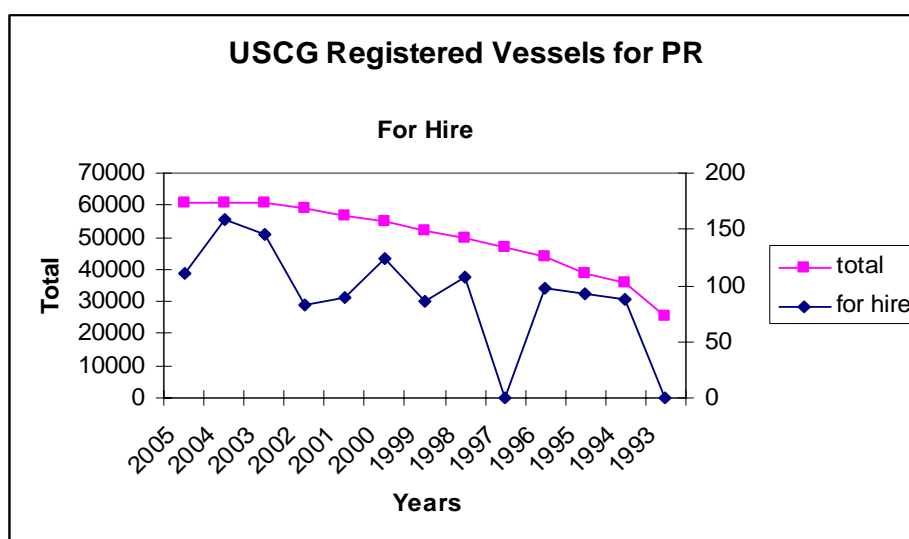
Eastern Caribbean Center survey (2002) found that trolling was reported as the most common boat-based fishing method in the USVI (59.7%), followed by bottom fishing (22.7%). However, Jennings (1992) states that bottom fishing (70%) was more common than trolling (20%) in 1986. Eastern Caribbean Center (2002) found that about half (53.3%) the USVI recreational fishermen fished in territorial waters (< 3 mi from shore), while 46.7% fished in federal waters. The most preferred fish group was snappers, followed by dolphin and tuna, and the majority of the catch (72.9%) was used for personal consumption. On average USVI boat-based fishermen make two fishing trips a month and fish about 4 hours per trip (Eastern Caribbean Center 2002). The total USVI boat-based recreational fishing hours in 2000 was estimated to be 320,204 hours.

The average cost of a USVI recreational fishing trip was \$125.11, which included gear, bait, ice, refreshments, food, fuel, launching fees, lodging, auto transportation, and charter and guide fees, among other costs (Eastern Caribbean Center 2002). Most gear was purchased in the USVI (77%), but about half of the electronics were bought outside the USVI. Average USVI boat ownership costs were about \$2,104.13 annually. Total boat-based recreational fishing expenditures in the USVI in 2000 were approximately \$5.9 million, with St. Thomas/St. John contributing about \$4.8 million to the total.

#### 4.4.7. Boats

All recreational vessels in Puerto Rico must be registered with the DNER. There are a number of charter boats (trolling and bottom fishing), diving boats, shoreline fishermen, and recreational fishing boats (privately-owned vessels) but information on fishing effort, catch, or other information is largely unknown. Most of the information available from the recreational fishing sector deals with tournament data on species such as marlin and dolphin.

The total number of recreational boats registered in Puerto Rico in 1995 (DNER 1995 unpublished data) was reported as 35,931 registered vessels – including personal watercrafts (jet skis). The total number of boats registered in Puerto Rico during 1996 was 44,049, indicating an increase of 8,118 boats in one year. The total number of registered vessels (also including jet skis) in Puerto Rico during 2005 was 61,026. The number of for-hire (passenger and commercial other than commercial fishing vessels) was 93 (for 1995), 98 (for 1996) and 111 for 2005. The figures below show the number of registered vessel for Puerto Rico, by size, from 1993 to 2004(2005).



From 2004 to 2005, the number of for-hire vessels decreased from 159 to 111. No explanation is available for the drop in for hire vessels.

Eastern Caribbean Center (2002) reported 2,462 registered boat owners in the USVI, with 566 of these from St. Croix and 1,896 from St. Thomas/St. John. However, the number of

recreational vessels registered in the USVI in 1997 was estimated to be 5,000 (L. Roberts, USVI/DPNR Division of Environmental Enforcement personal communication). In addition, numerous other recreational vessels are reported in transit through the USVI. Average USVI recreational boat length is 22.8 ft, with most (81.6%) less than 30 ft, while only 5% were 40 ft or greater in length (Eastern Caribbean Center 2002). Downs et al. (1997) found eight charter fishing businesses operating in St. Thomas and two in St. John run mostly by “continentals” from the mainland U.S., with vessel sizes ranging from 25 to 48 feet in length. None of these vessels was licensed to carry more than six passengers, and the larger vessels were crewed by a captain and mate. These charter vessels tended to target pelagic fishes and sharks, and the catch not retained by customers was sold to restaurants and hotels. The fees for charter and commercial boats are \$37.50, \$75.00, \$150.00, \$225.00 and \$300.00 for vessels in the categories < 16’, 16 – 26’, 26 – 40’, 40 – 65’ and >65’. The recreational vessels in the same categories pay a fee of \$25, 50, 100, 150 and 200.

García-Moliner et al. (2002) found that fishing charter activity has increased in the U.S. Caribbean since the survey by (Downs; J.S. Petterson; E. Towle, and L.L. Bunce 1997). In 2000, a survey identified 46 year-round charter-fishing operations, 27 in the USVI and 19 in Puerto Rico. These operations included 60 vessels. Additional seasonal operations exist during the June-September blue marlin season. Most of the charter vessels fish off shore and target pelagic species, but some offer inshore and reef fish trips as well. The charter industry considered reef fish availability as “fair.” Charter and head boats are not required to maintain records and there is no information available to describe activities of these groups, targeted species, effort, etc. Establishment of needed socioeconomic research and expanded data collection from charters is necessary to assess the US Caribbean fisheries. Both the yellowfin grouper and the mutton snapper are listed in the surveys as target species. No data are available on the amount of fish harvested.

Of over 100 dive-charter operations in the U.S. Caribbean, 37% of those in Puerto Rico and 21% of those in the USVI allowed fishing ((Garcia-Moliner; W.R. Keithly, and I.N. Oliveras 2001)). Fishing during dive trips targeted lobsters, queen conch (hand harvest) and fish (spear fishing).

#### 4.4.8. Charter

The for-hire boating activity has changed considerably over the years. The sport fishing industry for highly migratory species such as the blue marlin was the predominant sector of the charter operations. Figure of the for-hire vessels from 1993 to 2005 shows the changes in the industry. There are missing data for 1993, 1997 and 2005, and changes in the reporting that merit further investigation. The for-hire vessels carrying more than 6 passengers are required, among other things, a USCG Captain license. Efforts are being made to acquire any data that are available to further identify the charter operations in the US Caribbean.

The work done in the 1970s and 1980s pointed to the potential development of these activities in the US Caribbean (e.g., (CLARK; DITTON and others 1994), (CHAPARRO 1992), (VALDES-PIZZINI and others 1988), (VALDES-PIZZINI and others ), (VALDES-PIZZINI 1986)). At the time, there was information on the cost of operation, the investment and return of

recreational fishing, etc. Recent studies on the socio-economics of the charter and recreational fishing sectors are not available.

Over the past few decades there has been further development of the near shore for hire fishing operations with diversification to include: the flats (tarpon and snook), the reefs (groupers and snappers) ((Thoemke 2000), (GARCIA-MOLINER and others 2002)), the near shore pelagics such as mackerels and the dolphin and wahoo in addition to the well established fleet for marlin and other bill fish and tuna.

#### 4.4.9. Problems and Recommendations

The information and data that is currently not available is directly relevant to disseminating the status of managed marine resources (e.g., MSY, OY, etc.), as well as evaluating potential impacts resulting from any proposed management alternatives. Because of the lack of discrete biological data for the U.S. Caribbean, managers are handicapped and must rely on related studies conducted, and information gathered, in other geographic areas.

The first attempt through Dingell-Johnson funds to collect recreational (sports) fishing data was in 1973 (PRDNER –Suarez-Caabro El Mar de Puerto Rico 1979). A total of 1,564 questionnaires were sent out, receiving 296 in return of which 284 were active sports fishers in 1972-1973. In 1971, the 284 fishers landed 215,000 lbs and based on this an estimated 1,000,000 lbs were reported as landed by the sportfisher in Puerto Rico. At the time there were an estimated 2,500 boats between 20 and 45' for sport fishing. Sixty five per cent (65%) of the respondents had their own vessel and mostly fished with rod and reel. The most commonly landed fish were groupers (*Epinephelus* sp.) but, by weight, the most landed were blue marlin and dolphin fish. Schmied (1989) reported 81,000 resident marine recreational fishers (over 23,000 boats) for Puerto Rico. The reports for D-J have been requested from PR DNER (follow up).

The most recent published information on recreational fishing activity, other than for pelagic species, dates back to 1986 (Jennings, 1992) in the U.S. Virgin Islands, and 1989 in Puerto Rico. Jennings (1992), from a telephone survey conducted in 1986, indicates that in St. Croix the proportion of anglers fishing from the shoreline is higher than in St. Thomas/St. John. Bottom fishing and trolling from recreational vessels were the most frequent fishing activities targeting reef fish and were most common in St. Thomas.

A total of 814 anglers were counted on St. Croix, of which 404 were interviewed. The highest fishing effort took place in the afternoon hours and during the months of May through July. Most of the fishing areas however are nursery grounds where juveniles of species occur. The U.S. Virgin Islands Division of Fish and Wildlife, Department of Planning and Natural Resources (DPNR) is currently assessing the recreational fishery of the U.S. Virgin Islands.

Recreational fishing activity has continued to increase but with little data collection effort. This activity has always been assumed to be for sport and pleasure and with the ultimate fate of the product to be consumed at home – for personal use or be given away; not entered into commerce. It is primarily in tournaments that the amount of fish harvested exceeds the “for personal use” definition. The disposition of the excess harvest is unknown.

There is a bag limit in place for the queen conch (across jurisdictions) that establishes a catch of three conchs per fisher to a maximum of 12 per boat per day. The sale of queen conch and fish by recreational fishers is currently prohibited.

Appendix 1: From Table 7 of the Comprehensive SFA Amendment (2005): Recreational and commercial catch for the US Caribbean (requested update will be available after March 2007)

Table 7. Continued.

REEFFISHES					
GRUNTS	172,960	25,168	198,128	87%	13%
GRUNT, WHITE					
PORKFISH					
MARGATE					
GRUNT, BLUESTRIPED					
GRUNT, FRENCH					
GRUNT, TOMTATE					
GRUNTS, UNC					
GOATFISH	22,752	1,995	24,747	92%	8%
GOATFISH, SPOTTED					
GOATFISH, YELLOW					
GOATFISHES, UNC					
PORGIES	41,143	3,947	45,090	91%	9%
PORGIES, UNC					
PORGY, JOLTHEAD					
SEA BREAM					
PORGY, SHEEPSHEAD					
PORGY, PLUMA					
SQUIRRELFISH	19,104	8,710	27,814	69%	31%
BIGEYE					
SQUIRRELFISH, LONGSPINED					
SQUIRRELFISHES, UNC					
SOLDIERFISH, BLACKBAR					
SQUIRRELFISH					
TILEFISH	667	2,331	2,998	22%	78%
TILEFISH, UNC					
TILEFISH, BLACKLINE					
TILEFISH, SAND					
JACKS	117,226	220,802	338,028	35%	65%
BLUE RUNNER					
HORSE-EYE JACK					
BLACK JACK					
ALMACO JACK					
BAR JACK					
GREATER AMBERJACK					
JACK, YELLOW					
JACKS, UNC					
PARROTFISHES	278,244	38,593	316,837	88%	12%
PARROTFISH, BLUE					
PARROTFISH, MIDNIGHT					
PARROTFISH, PRINCESS					
PARROTFISH, QUEEN					
PARROTFISH, RAINBOW					
PARROTFISH, REDFIN					
PARROTFISH, REDTAIL					
PARROTFISH, STOPLIGHT					
PARROTFISH, REDBAND					
PARROTFISH, STRIPED					
PARROTFISH, UNC					

Table 7. Continued.

SURGEONFISH TANG, BLUE SURGEON, OCEAN DOCTORFISH SURGEONFISHES, UNC	34,883	833	35,716	98%	2%
TRIGGERFISH FILEFISH FILEFISH, SCRAWLED FILEFISH, WHITESPOTTED TRIGGERFISHES, UNC TRIGGERFISH, OCEAN DURGON, BLACK TRIGGERFISH, SARGASSUM TRIGGERFISH, QUEEN	110,090	98,228	208,278	53%	47%
BOXFISH BOXFISH, UNC COWFISH, HONEYCOMB COWFISH, SCRAWLED TRUNKFISH TRUNKFISH, SPOTTED TRUNKFISH, SMOOTH	108,428	5,624	114,052	95%	5%
WRASSES HOGFISH, SPANISH WRASSES, UNC PUDDINGWIFE HOGFISH	58,602	9,798	68,400	86%	14%
ANGELFISH ANGELFISH, QUEEN ANGELFISH, GRAY ANGELFISH, FRENCH	6,391	1,688	8,079	79%	21%
<b>Finfish Total =</b>	<b>2,286,550</b>	<b>1,901,735</b>	<b>3,296,285</b>	<b>70%</b>	<b>30%</b>
<b>SPINY LOBSTER FMP</b>					
LOBSTER, SPOTTED SPINY LOBSTER, SPINY	370,856	175,784	546,640	66%	32%
<b>QUEEN CONCH FMP</b>					
CONCH OTHER CONCH	287,364 1,516	151,584 0	438,948 1,516	65% 100%	35% 0%
<b>GranTot =</b>	<b>2,948,386</b>	<b>1,329,183</b>	<b>4,277,489</b>	<b>69%</b>	<b>31%</b>

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## 5. Indices Of Abundance

Tables 5-1 and 5-2 summarize the available indices of abundance and potential data sets for developing indices of abundance of queen conch, yellowfin grouper, and mutton snapper in Puerto Rico and the U.S. Virgin Islands. The data sources, units, available years, and methodologies used to construct indices for the data workshop are summarized in Table 5-1. The recommendations of the SEDAR 14 DW index of abundance working group for use of the various known data sets are described in detail below, and in Table 5-2.

### 5.1. Fisheries Dependent Indices

A number of indices were developed for queen conch in Puerto Rico and the US Virgin Islands using available commercial effort and landings data. Models developed by Valle-Esquivel for the 2002 assessment were used, as well as, newly developed models.

Nominal CPUE series from Puerto Rico commercial effort and landings data were prepared for yellowfin grouper and mutton snapper. A number of data issues were presented in plenary for discussion and clarification.

#### 5.1.1. Puerto Rico Queen Conch

##### 5.1.1.1. General Description:



The construction of the commercial handline index is described in the document SEDAR 14-DW-5.

Landings and fishing effort of commercial vessels operating in Puerto Rico are monitored by the Fisheries Research Laboratory of the Puerto Rico Department of Natural and Environmental Resources (DNER). The program collects landings and effort data from coastal municipalities and major fishing centers in Puerto Rico. The available catch per unit effort (CPUE) series, from 1983 – 2005 were used to develop several abundance indices for queen conch. An initial series of indices were developed using the models of Valle-Esquivel (2002a) from a previous queen conch assessment. New models were also developed for Puerto Rico and southwest Puerto Rico.

In Puerto Rico fishers may report multiple trips on a single sales record (report to DNER). Only single trip records were included in the dataset. Two approaches were used to define single record trips and an index was constructed for each approach. One approach defined single trip records if the sales record indicated that trips=1 or if trips was reported as 0 or if number of trips was missing (Valle-Esquivel, 2002b). A second approach included only those data that included trips=1 on the sales record. Trips were additionally limited to those that reported SCUBA, skin diving, or spear fishing as the fishing gear used.

#### *Puerto Rico lognormal 2002 model*

Indices of abundance were constructed using the lognormal model of Valle-Esquivel (2002a). Following Valle-Esquivel's methods, trips that reported landings beyond 99.5% of the combined multispecies cumulative distribution of landings or less than 1% of the conch landings distribution were excluded from the analyses. A factor, COAST, was included that divided the island into four regions: north (fishing centers 10-170), east (180-251), south (260-362), and west (370-423; see Valle-Esquivel, 2002b for a map of these locations). This definition of COAST differs from Valle-Esquivel (2002a) in that there are only four regions defined rather than seven. This was done to ensure larger sample size for the analyses. Year, month, and gear were also included as additional factors in the analysis. CPUE was defined as pounds of conch landed per trip. The Valle-Esquivel 2002 lognormal model was fit using the procedure Proc Mixed in SAS and included a correction of log transform bias modified from an algorithm developed by Lo et al. (1992).

#### *Puerto Rico delta lognormal 2002 model*

A second pair of indices was constructed using the Valle-Esquivel 2002 delta lognormal model. The dataset used to construct two indices including factors similar to those described for the lognormal (positive trips) indices above. Trips in the delta lognormal analyses included all trips with the reported gears SCUBA, skin diving, and spear fishing with the pounds landed limitations listed above. The assumption was that such trips had the potential to catch conch. The development of the delta lognormal indices included a binomial model of the proportion positive trips in addition to the lognormal model on positive trips following the methods of Lo et al. (1992). The two definitions of single trips (trips=1, 0, or missing vs. trips=1), coast, month, and year were again included separately in two versions of the final model (Valle-Esquivel, 2002a).

### Southwest Puerto Rico lognormal 2002 model

The dataset used to construct these indices was limited to trips landing conch in southwestern Puerto Rico (fishing centers 370-384) and included significant factors from the Valle-Esquivel 2002 lognormal model for southwest Puerto Rico. Only positive trips were included in these analyses and the two definitions of single record trips (trips=1, 0, or missing and trips=1) limited the dataset for the analyses. The factor COUNTY (Lajas, Cabo Rojo, and Mayaguez; see Valle-Esquivel, 2002a for a map of these locations) was included rather COAST (Valle-Esquivel, 2002a). Other factors were similar to the previous analyses. The index was developed following the methods described for the Puerto Rico lognormal 2002 model.

#### Additional Indices

Additional lognormal and delta lognormal indices were developed for Puerto Rico and southwest Puerto Rico. The two approaches to defining single record trips (i.e. trips=1, 0, missing vs. trips=1 reported on the sales record) were used to develop separate indices. Data were further limited by including only trips that reported using SCUBA, skin diving, or spear fishing and excluded trips that reported landings beyond 99.5% of the combined multispecies cumulative distribution of landings or less than 1% of the conch landings distribution.

##### 5.1.1.2. Index Development

For the Puerto Rico lognormal and delta lognormal indices, seven factors were considered as possible influences on the CPUE and the proportion of positive trips:

Factor	Levels	Value
YEAR	23	1983-2005
MONTH	12	January-December
WAVE	6	Two month periods; January-February, etc.
SEASON	4	Three month periods; January-March, etc.
GEAR	3	SCUBA, skin diving, spear fishing
COAST	4	North, east, south, west as defined above
TARGET*	2	1=only conch landed, 0=other species landed, may also have landed conch

\*TARGET was excluded from the binomial portion of delta lognormal analyses because all TARGET=1 trips are positive

An initial lognormal model on positive trips was developed for Puerto Rico. CPUE was defined as pounds of conch landed/trip. The final lognormal model was fit using the procedure Proc Mixed in SAS and included a correction of log transform bias modified from an algorithm developed by Lo et al. (1992).

The delta lognormal model approach (Lo et al., 1992) was also used to develop standardized indices of abundance for the conch data. This method combines separate GLM analyses of the proportion of successful trips (trips that landed conch) and the catch rates on successful trips to construct a single standardized CPUE index.

### Southwest Puerto Rico

Indices developed from southwest Puerto Rico data followed the methods and data limitations listed above for the indices constructed for the whole island. For the southwest

Puerto Rico lognormal and delta lognormal indices, five factors were considered as possible influences on the CPUE and the proportion of positive trips:

Factor	Levels	Value
YEAR	23	1983-2005
SEASON	4	Three month periods; January-March, etc.
GEAR	3	SCUBA, skin diving, spear fishing
COUNTY	3	Fishing centers of Lajas, Cabo Rojo, and Mayaguez
TARGET*	2	1=only conch landed, 0=other species landed, may also have landed conch

\*TARGET was excluded from the binomial portion of delta lognormal analyses because all TARGET=1 trips are positive

#### 5.1.1.3. Results:

#### Replication of 2002 Puerto Rico indices

##### Puerto Rico Lognormal

The updated indices were very similar regardless of how trips were defined and were generally similar to the 2002 index over the second half of the time series beginning in 1992 (Figure 5-1). Until 1989, the updated indices had highly variable mean CPUEs and differed from the 2002 index during 1984 and 1986. Relative abundance indices and coefficients of variation are provided in Table 5-3. Since 1990 there was no apparent trend in CPUE in either the updated indices or the 2002 index. Differences between the updated indices and the 2002 index may be due to updated data and edits of those data. Sample sizes are generally low during the first five years of the time series and any data edits may have a substantial effect on the analyses. Also, redefining COAST to ensure adequate sample size probably explains some of the observed differences. The reliability of the Puerto Rico landings and effort data prior to 1989 were questioned during plenary session at the SEDAR 14 data workshop. During those years the data collection program was beginning and data collection was not fully standardized. It was recommended that data from those years be excluded from analyses.

##### Puerto Rico Delta-lognormal

The updated delta-lognormal indices (trips=1, 0, or were missing and trips=1) are similar to the 2002 index (Figure 5-1), although there are differences in some years, particularly prior to 1989. Relative abundance indices and coefficients of variation are provided in Table 5-3. As with the lognormal indices, differences may be due to data updates and editing completed since 2002 and the redefined factor COAST. CPUEs varied considerably over time during the first six to seven years of each time series, perhaps due to the haphazard nature of early data collection. There was no clear trend in CPUE over the remainder of the series.

##### Southwest Puerto Rico Lognormal

The updated lognormal index (trips=1, 0, or were missing) was more similar to the 2002 index than the updated index developed from data where only trips=1 were included (Figure 5-1). After 1989 all three indices were in general agreement and none had any apparent trend in CPUE since 1989. Relative abundance indices and coefficients of variation are provided in Table 5-3. Minor differences in the 2002 index and the updated index (trips=1, 0, or missing)

may, again, be due to problems during the initial years of data collection and subsequent data editing since 2002.

#### Additional Puerto Rico Indices

##### *Puerto Rico lognormal indices*

Relative abundance indices and coefficients of variation are provided in Table 5-4. The standardized indices are provided in Figure 5-1. These two indices are very similar, with large variability early in the time series and no apparent trend in CPUE since 1990.

##### *Puerto Rico delta-lognormal indices*

Relative abundance indices and CVs are provided in Table 5-4. The delta-lognormal Puerto Rico standardized abundance indices are shown in Figure 5-1. These two indices differed in a few of the initial years of the time series and diverged again beginning in 1998. CPUEs for trips=1 were slightly higher over the last seven years of the series.

##### *Southwest Puerto Rico lognormal indices*

Relative abundance indices are shown in Figure 5-1. Relative abundance indices and coefficients of variation are provided in Table 5-5. These two indices differ little aside from some differences early in the time series. Neither had a strong trend in CPUE since 1990, although there was a slight increase in mean CPUE over the 1990-2005 period. As in the other Puerto Rico indices, data collection issues prior to 1989 may be the cause of the highly variable CPUEs during the beginning of this time series.

##### *Southwest Puerto Rico delta-lognormal indices*

Relative abundance indices and CVs are provided in Table 5-5. The delta-lognormal southwest Puerto Rico standardized abundance indices are shown in Figure 5-1. These two indices differed greatly only in 1988, however they were both much lower in the first two years of the series than were the CPUEs of the lognormal indices for southwest Puerto Rico. In addition, the delta-lognormal indices had higher CPUEs in 1992 and 1993 than did the lognormal indices. Over the last 11 years, however, all the indices were in close agreement and showed no strong trend in CPUE, although there has been perhaps a slight increase in mean CPUE.

#### 5.1.1.4. Utility:

The SEDAR 14-DW working group recommends further exploration of the Puerto Rico dataset that should include constructing revised indices with the following guidelines:

- 1) eliminate data from the years prior to 1989
- 2) include only those trips clearly labeled as “Trips=1”
- 3) include only those trips landed from fishing centers identified as having conch landings or that had >1% of reported landings and were contiguous with other centers identified as important for conch landings
- 4) include only those trips where scuba, skindiving, or spearfishing were reported as the gear used

- 5) exclude trips reported during the closed season (closed July-September beginning 1996 in Federal waters and 1999 in territorial waters)
- 6) convert landed pounds reported per trip beginning in 2003 to account for changes from uncleaned to cleaned conch landings; for 2003 landings should be divided by 0.833 (50% of landings were cleaned) and 2004-2005 landings should be divided by 0.667 (100% of landings were cleaned)
- 7) examine the feasibility of identifying lobster trips and eliminating them from the conch data set

### 5.1.2. Puerto Rico Commercial Yellowfin Grouper

#### 5.1.2.1. Data sources and Methods

Data concerns and approaches to construction of possible commercial yellowfin grouper indices are described in the document SEDAR 14-DW06.

Preliminary information on commercial nominal landings and catch per unit of effort (CPUE) of yellowfin grouper (Cummings and Matos-Caraballo 2006) was discussed by the SEDAR DW participants. Data sources and a description of the data were included. The source of this data set is the commercial finfish sales records collected by the Puerto Rico Department of Natural Environment and Resources (DNER), Fisheries Statistics Program (FSP) and was available electronically since about 1983 (Matos-Caraballo, 2004). Information recorded on each sales record usually included: the date (year, month, day) the landed catch was sold, fisherman identification, municipality and fishing center, and gear used. Sometimes, but not continuously, information was also recorded on: gear quantity, number hours fished, and the minimum and maximum depth fished. Each sales record included an additional variable, NTRIPS, representing the number of unique fishing trips that represent the landed catch. Thus, a single sales record could be reflective of one or more fishing trip events. The complete dataset of commercial sales records included observations sales of finfish and shellfish for 1983-2005. Data for 2006 are not yet available.

For purposes of calculating nominal CPUE for this study, the measure of catch was the landed weight in pounds. CPUE was computed as the landed weight per trip. Although some records included information recorded for gear quantity or hours fished, the majority of records did not therefore the unit of effort was a fishing trip. As mentioned previously, sometimes a sales record reflected the combined landings from more than a single trip. For these multi-trip records, CPUE was computed as landings weight divided by the number of trips.

#### 5.1.2.2. Preliminary results on yellowfin grouper nominal commercial CPUE

Sales of yellowfin grouper occurred in all years since the 1987. The distribution of the landings by gear categories, as reflected in the sales records, was used to identify the primary gears employed in harvesting yellowfin grouper in Puerto Rico. This information indicates that landings of yellowfin grouper in Puerto Rico have been from three main gears historically: dive (37% of landings by weight), traps (34%), and hook and line (26%).

The data set was also evaluated in terms of the number of observations for each of these three gears across all years, 1983-2005, that could be included in subsequent general linear model analyses of these data. It should be noted that in most years less than 100 sales records

were reported landing yellowfin grouper across all gears (Table 5-6), thus concerns regarding models containing a large number of parameters was raised by some in the group.

Criteria for data exclusion in further CPUE analyses were considered next. The distribution of values recorded for the 'NTRIPS' variable was also examined for the yellowfin grouper data. Values ranging from 0, missing, 1 up to and including NTRIPS='43' were recorded in the data. The SEDAR 14 participants further discussed procedures to be used to select data for inclusion in the CPUE calculations. Previously, SEDAR8 yellowtail snapper evaluations only included observations of landings in the CPUE analyses in which the NTRIPS variable was less than or equal to 7. A about 69% of the yellowfin grouper sales observations had the 'NTRIPS' variable coded as '1'. Records for which the NTRIPS variable was coded as '0' or 'blank' were eliminate from the analyses as was previously done in SEDAR 8 yellowtail snapper analyses and also for this SEDAR queen conch CPUE analyses. Figure 5-2 shows that the standard deviation of mean CPUE per trip of yellowfin grouper was much larger for records where NTRIPS was coded as '1', suggesting that some of these records could included multi-trip events. It was not clear from inspection of these statistics that selection of the input data for use in further CPUE calculations could be based on the 'NTRIPS' variable alone.

A discussion of possible modeling approaches of the yellowfin grouper Puerto Rico CPUE data took place. It was recommended that a simple general linear model be used containing auxiliary terms that included: year, month (or season), geographical area (municipality or fishing center) and gear for reducing the variation in CPUE. Based on the preliminary nominal CPUE examinations and also a criterion of requiring a minimum of 10 CPUE samples per cell it was recommended to have more extensive discussions by the fishery experts participating at the meeting (fishery agents and commercial fishermen) and the analysts regarding data selection. The task of this sub group was to further identify spatial areas in which yellowfin grouper could be expected to be found biologically and also could be expected to be fished during the year.

Yellowfin grouper nominal CPUE by gear for the years 1983-2005 is presented in Table 5-7.

#### 5.1.2.3. Utility:

The SEDAR 14-DW working group recommends further exploration of the Puerto Rico dataset that should include constructing indices with the following guidelines:

- 1) two fishery sampling agents, in addition to a commercial fisherman from the southwest coast of Puerto Rico, identified specific municipalities to be included in further CPUE examinations. During some of the discussion, an additional agent from the east coast of Puerto Rico was called to confer on inclusion/exclusion of a particular fishing area. These recommendations will be used to restrict data selection to specific areas.
- 2) the agents reviewed the individual data file and identified several observations that were key punch errors and should be deleted from the dataset. These suggestions would be used to remove outliers from the data set. In addition, port agents and fishers recommended excluding trips with reported landings of yellowfin grouper of 1,000 pounds or more.

3) the group participants recommended including in the analysis trips that could have potentially landed yellowfin grouper but did not (zero catch trips). In order to carry out this task, re-construction of trips is necessary. It was recommended that unique trips be identified for years where the unique trip identification variable was not recorded (i.e., prior to 2003) by using a computer generated variable that included information on date landed, fisherman id, municipality, fishing center, gear, and NTRIPS variable. Finally as part of this third task, the group made the recommendation to incorporate species information into the selection of zero trips. Although the group did not select a single method for selecting zero trip landings, it was recommended to consider the Stephens and MacCall (2004) approach and also possibly to include zero trips from records that also caught one of the other grouper species from the yellowfin grouper management unit. These recommendations will be used to aid in selection of zero trip records.

### 5.1.3. Puerto Rico Commercial Mutton Snapper

#### 5.1.3.1. Data sources and Methods

Data concerns and approaches to construction of the commercial mutton snapper index are described in the document SEDAR 14-DW7.

Preliminary information on commercial nominal landings and catch per unit of effort (CPUE) of mutton snapper (Cummings and Matos-Caraballo 2006) was discussed by the SEDAR DW participants. Data sources, a description of the available data, and calculation of CPUE were as described in section 5.1.2.

#### 5.1.3.2. Preliminary results on mutton snapper nominal commercial CPUE

Landings of mutton snapper occurred in all years since the 1983. The distribution of the landings by gear categories, as reflected in the sales records, was used to identify the primary gears employed in harvesting mutton snapper in Puerto Rico. This information indicates that four main gears have historically been used to harvest mutton snapper in Puerto Rico: traps, hook and line, nets, and dive gear on occasion. Historically, traps harvested about 32% of the total combined landed weight across all years and hook and line gear harvested about 40%. Nets and dive gear harvested about 14% and 10% each.

The data set was also evaluated in terms of the number of observations of CPUE available for each of major gears across all years, 1983-2005. In some years the number of samples of CPUE approaches 25 or fewer for a particular gear, indicating that the number of terms included in a general linear model applied to the data might be limited (Table 5-8).

Criteria for data exclusion in further CPUE analyses were considered next. The distribution of values recorded for the 'NTRIPS' variable was examined for the mutton snapper data. Values ranged from 0, missing, 1 up to and including NTRIPS='99'. The SEDAR 14 participants further discussed procedures to be used to select data for inclusion in the CPUE calculations. Previously, SEDAR8 yellowtail snapper evaluations only included observations of landings in the CPUE analyses in which the NTRIPS variable was less than or equal to 7. About 68% of the mutton sales (landings) observations had the 'NTRIPS' variable coded as '1'. Records for which the NTRIPS variable was coded as '0' or 'blank' were eliminated from the

analyses as previously done in SEDAR 8 yellowtail snapper analyses and also for this SEDAR queen conch CPUE analyses. Figure 5-3 shows that the standard deviation of mean CPUE per trip of mutton snapper was much larger for records where NTRIPS was coded as '1', suggesting that some of these records may have included multi-trip events. It was not clear from inspection of these statistics that selection of the input data for use in further CPUE calculations could be based on the 'NTRIPS' variable alone.

A discussion of possible modeling approaches of the mutton snapper Puerto Rico CPUE data took place. It was recommended that a simple general linear model be used containing auxiliary terms that included: year, month (or season), geographical area (municipality or fishing center) and gear for reducing the variation in CPUE. Based on the preliminary nominal CPUE examinations and also a criterion of requiring a minimum of 10 CPUE samples per cell it was recommended to have more extensive discussions by the fishery experts participating at the meeting (fishery agents and commercial fishermen) and the analysts regarding data selection. The task of this sub group was to further identify spatial areas in which mutton snapper could be expected to be found biologically and also could be expected to be fished during the year.

Mutton snapper nominal CPUE by gear for the years 1983-2005 is presented in Table 5-9.

#### 5.1.3.3. Utility:

The SEDAR 14-DW working group recommends further exploration of the Puerto Rico dataset that should include constructing indices with the following guidelines:

- 1) two fishery sampling agents, in addition to a commercial fisherman from the southwest coast of Puerto Rico, identified specific municipalities to be included in further CPUE examinations. During some of the discussion, an additional agent from the east coast of Puerto Rico was called to confer on inclusion/exclusion of a particular fishing area. These recommendations will be used to restrict data selection to specific areas.
- 2) the agents reviewed the individual data file and identified several observations that were key punch errors and to be deleted from the dataset. These suggestions will be used to remove outliers from the data set. In addition, port agents and fishers recommended excluding trips reporting landings of more than 3,000 pounds of mutton snapper.
- 3) the group participants recommended that trips be included in the analysis where mutton snapper could potentially have been caught. In order to carry out this task, reconstruction of trips is necessary. It was recommended that unique trips be identified for years where the unique trip identification variable was not being recorded (i.e., prior to 2003) by defining individual trips as data with unique combinations of the variables date landed, fisherman id, municipality, fishing center, gear, and NTRIPS. Finally as part of this third task, the group made the recommendation to incorporate species information into the selection of zero trips. Although the group did not select a single method for selecting zero trip landings, it was recommended to consider the Stephens and MacCall (2004) approach and also investigate the possibility of including zero trips from records



that also caught one of the other snapper species from the mutton snapper management unit. These recommendations would be used to aid in selection of zero trip records.

Following the Data Workshop the recommendations above in items 1-3 will be carried out and used to generate new data sets which would be further evaluated with general linear models for mutton snapper in Puerto Rico.

#### 5.1.4. Us Virgin Islands Commercial Conch

##### 5.1.4.1. General Discussion:

The construction of the commercial indices is described in the document SEDAR 14-DW-5. In the US Virgin Islands, commercial fishers report catch and effort data on a monthly basis to the US Virgin Islands Division of Fish and Wildlife (DFW). A separate data set is maintained for St. Croix, but data from St. Thomas and St. John are contained in a single database.

The available catch per unit effort (CPUE) series, from 1986-2005 were used to develop several abundance indices for queen conch. An initial abundance index for St. Croix was developed using the model of Valle-Esquivel (2002a) from a previous queen conch assessment. New models were also developed for St. Croix and for St. Thomas/St. John.

##### 5.1.4.2. Methods:

##### *St. Croix lognormal (positive trips) 2002 model*

This index was constructed from a dataset that included all trips reporting conch landings, regardless of gear used. The dataset included conch landings and effort for the years 1989-2005. Area was defined as southwest, southeast, east, northeast, northwest, and west St. Croix. The index was developed using the 2002 model of Valle-Esquivel.

##### *St. Croix 2007 lognormal model*

Methods used to construct an additional index of abundance from St. Croix conch landings and effort information followed the methods previously described for developing the Puerto Rico lognormal models. All trips that reported conch landings were included in the analysis, regardless of the gear employed. Data for the years 1986, 1988, and 1999 were excluded from the analysis because data from those years were insufficient for the analysis. For the St. Croix lognormal index, three factors were considered as possible influences on the CPUE per trip:

Factor	Levels	Value
YEAR	17	1987, 1990-2005
SEASON	4	Three month periods; January-March, etc.
AREA	6	Northeast, east, southeast, southwest, west, and unknown

##### *St. Thomas/St. John*

Methods for constructing the lognormal index for St. Thomas and St. John were similar to those used to develop previously described lognormal indices. All positive conch trips were included in the dataset. Data for the year 1986 were insufficient for the analysis and the years

1988-1994 were excluded because the fishery was closed. For the St. Thomas/St. John lognormal indices, three factors were considered as possible influences on the CPUE and the proportion of positive trips:

Factor	Levels	Value
YEAR	12	1987, 1995-2005
SEASON	4	Three month periods; January-March, etc.
AREA	3	North of the islands, south of the islands, unknown

#### 5.1.4.3. Results:

##### Replication of 2002 St. Croix lognormal

The updated index differs from the 2002 index, but most of those differences are minor and overall trends in each index are similar (Figure 5-4). Relative abundance indices and coefficients of variation are provided in Table 5-10. Yearly differences in CPUE between indices, as with the Puerto Rico indices, may be due to data updates since 2002. For example, data were insufficient from 1998 to include that year in constructing the 2002 index, however additional data now included in the St. Croix dataset allowed for 1998 to be added to the time series. The updated index has a clear decreasing trend during 1989-1992, but no obvious trend after 1992. In the 2002 index, that initial decreasing trend is less clear and a slight increasing trend is apparent from 1998-2001. In the updated index, that trend is less apparent.

##### Additional USVI indices

##### St. Croix lognormal index

Relative abundance indices are shown in Figure 5-4. Relative abundance indices and coefficients of variation are provided in Table 5-10. The index has a steady decline in CPUE over the first four years of the continuous series, however the CPUE calculated for these data from 1987 is lower than the 1990 and 1991 mean CPUEs. After 1993 there was, perhaps, a very slight increase in CPUE through 2005.

##### St. Thomas/St. John lognormal index

The standardized CPUE series is shown in Figure 5-4. Relative abundance indices and coefficients of variation are provided in Table 5-10. The index had a much higher CPUE in 1987 than was observed in the continuous portion of the index (1995-2005). During that period, the index showed no trend, although CPUE in 2005 was somewhat lower than other years. No index was developed for the 2002 assessment due to insufficient data. The dataset used to generate this index included 756 positive conch trips over the entire time series.

#### 5.1.4.4. Utility:

The SEDAR 14-DW working group recommends the further exploration of the Virgin Islands dataset and construction of indices of abundance with the following recommendations:

- 1) exclude west and northwest St. Croix from the analyses because conch do not occur in those areas
- 2) exclude years 1988-1993 in St. Thomas/St. John analysis (harvest prohibited)
- 3) include only scuba trips in the analyses

- 4) exclude scuba trips that reported more than 100 pounds of parrotfish landed, those trips involved net fishing for parrotfish and were likely not in conch habitat
- 5) determine hours fished per vessel and include that information as a measure of effort
- 6) exclude 1987 data from the St. Thomas/St. John analysis
- 7) determine if data are adequate for construction of a St. Thomas/St. John index
- 8) exclude trips from July-September (harvest prohibited)
- 9) assume trips with reported landings of “shellfish” or “unclassified shellfish” were reporting conch landings
- 10) include trips with reported gears of “freediving”, “scuba”, or “unknown”
- 11) examine the feasibility of identifying lobster trips and eliminating them from the conch data set

#### 5.1.5. Us Virgin Islands Commercial Yellowfin Grouper

No indices for US Virgin Islands yellowfin grouper were presented at the data workshop.

##### 5.1.5.1. Utility:

The SEDAR 14-DW working group recommends that available Virgin Islands commercial data be examined to determine its appropriateness for use in constructing standardized indices.

- 1) determine if data are adequate to develop separate indices for St. Croix and St. Thomas/St. John
- 2) examine the utility of the Stephens and MacCall 2004 species association method for defining yellowfin grouper trips
- 3) examine alternatives to recommendation 2 above for defining yellowfin grouper trips, e.g. a gear configuration based method
- 4) work with fishers/port agents to identify gear configurations and fishing areas specific to yellowfin grouper and to identify possible outliers in the data

#### 5.1.6. Us Virgin Islands Commercial Mutton Snapper

No indices for US Virgin Islands mutton snapper were presented at the data workshop.

##### 5.1.6.1. Utility:

The SEDAR 14-DW working group recommends that available Virgin Islands commercial data be examined to determine its appropriateness for use in constructing standardized indices.

- 1) determine if data are adequate to develop separate indices for St. Croix and St. Thomas/St. John
- 2) examine the utility of the Stephens and MacCall 2004 species association method for defining mutton snapper trips
- 3) examine the feasibility of identifying mutton snapper trips as all trips that reported landing any species within the mutton snapper fishery management unit
- 4) work with fishers/port agents to identify gear configurations and fishing areas specific to mutton snapper

### 5.1.7. Marine Recreational Fishery Statistics Survey (Mrfss)

#### 5.1.7.1. General Description:

Puerto Rico and US Virgin Islands yellowfin grouper and mutton snapper catch estimates, sampling fractions, and size data collected in the Marine Recreational Fishery Statistics Survey (MRFSS) are provided in SEDAR14-DW03. MRFSS is a sample-based survey of recreational fishers that provides information on participation, effort, and species-specific catch. The MRFSS sample design in the US Caribbean is based on an intercept survey of anglers and telephone survey of coastal households.

Data are available from Puerto Rico from 2000 to present, however data from the US Virgin Islands is only available for 2000. Yellowfin grouper catches were only reported during 2001 and 2003. Mutton snapper were reported in each year, 2000-2005 in Puerto Rico. No mutton snapper were reported from the US Virgin Islands during the single year available (2000). Only five yellowfin grouper have been observed and measured. Approximately 140 mutton snapper were weighted and measured. Catch estimates range from 5,700 to 25,300 mutton snapper per year and 250 to 935 yellowfin grouper per year. Effort was not reported in the SEDAR14-DW03 document, however those data are available.

MRFSS does not collect data on queen conch recreational landings.

#### 5.1.7.2. Utility:

The SEDAR 14-DW working group recommends that mutton snapper MRFSS data from Puerto Rico be examined to determine its appropriateness for use in constructing standardized indices.

- 1) examine the utility of the Stephens and MacCall 2004 species association method for defining mutton snapper trips in Puerto Rico
- 2) MRFSS US Virgin Islands data are insufficient for developing indices for any of the species of interest
- 3) MRFSS data are insufficient for developing indices of abundance of yellowfin grouper in Puerto Rico

## 5.2. Fisheries Independent Indices

A summary of available fishery independent data sources along with recommendations on their utility for the current assessments is provided in Table .

### 5.2.1. SEAMAP – Caribbean: Reef Fish Sampling

<b>Target:</b>	Reef fish	<b>Duration:</b>	1991 to present
<b>Coverage:</b>	western PR, south St. John	<b>Data:</b>	SEAMAP

#### 5.2.1.1. Description:

The Southeast Area Monitoring and Assessment Program for the Caribbean (SEAMAP-C) is a cooperative program between the National Marine Fisheries Service, the Dept. of Natural and Environmental Resources in Puerto Rico and the Dept. of Planning and Natural Resources, Division of Fish & Wildlife in the US Virgin Islands. Sampling is conducted in quadrants within a sample area defined for each island. Areas off St. Croix, St. Thomas, and western PR are

included. From 1992-2002, 1098 individual fish from 39 species were captured from St. Croix; 1490 fish from 65 species were captured from St. John. Across all years, only 17 species with more than 5 individuals were captured from St. Croix; 28 species with more than 5 individuals were captured for St John. SEAMAP-C is a multiyear data set, originally targeting red hind spawning areas but other species are taken by trap and hook-and-line sampling. Data from Puerto Rico have not been examined but are requested from SEAMAP.

#### 5.2.1.2. Pros:

Repeated sampling, same method across all locations, sampling deeper than divers, broad range of species, CPUE calculated as minutes of fishing time.

#### 5.2.1.3. Cons:

Interannual variability unknown, overall numbers of yellowfin grouper represent: by biomass: 2.07% (5 kg) in 1992/3, 4.87% (6.22 kg) in 1994/5, 0.48% (1.56 kg) in 1999/2000 of the catch for all gear types south of St. John. For frequency 2.01% (caught 10 times, rank 8) in 1992/3; 1.56% (caught 4 times, rank 9) in 1994/5; 0.41% (caught 3 times, rank 25). Mean sizes (SL cm +/- SD) ranged from 325.4 +/- 58.1 in 1992/3; 465.5 +/- 89.6 in 1994/5; and 267.7 +/- 136.6 in 1999/2000. No mutton snapper (0) caught in Virgin Islands sampling. only STJ and STX sampled, not STT

#### 5.2.1.4. Utility:

Conch-no, mutton snapper-no, yellowfin grouper-maybe yes, if data can be obtained in a timely manner.

### 5.2.2. Reef Fish Surveys (SEAMAP-like) (PR DNER)

<b>Target:</b>	Reef fish	<b>Duration:</b>	1988 to present
<b>Coverage:</b>	western PR, SE St. Thomas	<b>Data:</b>	DNER; SEAMAP

#### 5.2.2.1. Description:

Similar sampling program as SEAMAP surveys, predates SEAMAP. Multiyear data set, targeting reef fishes with trap and hook-and-line sampling. Extent of data unknown but requested.

#### 5.2.2.2. Pros:

Repeated sampling, same method across all locations, sampling deeper than divers, broad range of species, CPUE (calculated as minutes of fishing time).

#### 5.2.2.3. Cons:

Interannual variability unknown, sampling intensity not generally all that high, overall numbers of yellowfin grouper and mutton snapper (0) low

#### 5.2.2.4. Utility:

conch-no, mutton snapper-unknown, yellowfin grouper-maybe yes, if data can be obtained in a timely manner.

### 5.2.3. Territorial Coral Reef Monitoring [St. Croix And St. Thomas (By Univ. Of The Virgin Islands, USVI Div. Fish And Wildlife)]

**Target:** Reef fish and benthos      **Duration:** 2001 to present  
**Coverage:** USVI (St. Thomas/Croix)      **Data:** VI DFW

#### 5.2.3.1. Description:

Surveys of reef fish (transects and roving diver) and benthos (coral), expected to continue long-term

#### 5.2.3.2. Pros:

Common method between STX and STT/J, repeat surveys of same site, provides density estimates, roving diver includes elusive/cryptic species

#### 5.2.3.3. Cons:

Not all data readily available, numbers are low for both finfish species, short time series

#### 5.2.3.4. Utility:

mutton snapper-yes, yellowfin grouper-yes, conch-no; assuming data are available

### 5.2.4. Commonwealth Coral Reef Monitoring In Puerto Rico

**Target:** Reef fish and benthos      **Duration:** 2001 to present  
**Coverage:** Vieques, Desecheo,      **Data:** UPRM; DNER

#### 5.2.4.1. Description:

Surveys of reef fish and benthos (coral), expected to continue long-term. Some focus on deeper, shelf edge reefs. Dr. Garcia also has been involved with CariComp surveys (reef fish and benthos) of permanent stations and CFMC-funded deeper reef surveys (140-160 ft). Generally, all timed surveys rather than area-based.

#### 5.2.4.2. Pros:

Most spatially comprehensive around PR

#### 5.2.4.3. Cons:

Timed surveys, no true density methods, numbers reported low for both species 4 sightings of mutton snapper, 3 sightings of yellowfin grouper, no time-series.

#### 5.2.4.4. Utility:

mutton snapper-no, yellowfin grouper-no, conch-no

### 5.2.5. PR Deep Reef Surveys

A series of deep reef site assessments have been undertaken by Univ. of PR-Mayagüez (Dr. Reni Garcia) funded by the CFMC with NOAA Coral Reef Conservation Program funds. Surveys include 30, 40 and 50 m depths, replicate 10 m transects. At Desecheo, 2004-5, no mutton snapper or queen conch were recorded but yellowfin grouper were recorded at 30 m depth on two of five 10 x 3 m transects (on one: 1-25 cm, and on the other: 1-25 cm and 1-50 cm). At 40 m depth, 5 yellowfin grouper were recorded across 3 of 5 transects: 1-40cm; 3-60

cm; and 1-75 cm. At 50 m depth, 2 (1-40, 1-45cm) were recorded on 1 of 5 transects. In deep surveys around Vieques, mutton snapper were reported in 30-40 m depths, (1-40 cm) and also in 40m depth (1-60 and 1-75 cm) In work just completed at Bajo de Cico, 8 yellowfin grouper were reported on transects in 30-50 m depth. Earlier deep water surveys were conducted in 1980-84 (NMFS) depths of 90-180m showed the highest CPUE for mutton snapper (personal communication, Graciela García-Moliner,). Surveys conducted with the Johnson SeaLink by NMFS in 1985 also reported mutton snapper in 60-150 m depth. Although the numbers from the various deep water surveys do not provide enough observations for stock assessment, they help establish preferred depth ranges for mutton snapper and yellowfin grouper and point to the need for additional deep water surveys for certain species.

#### 5.2.5.1. Pros:

Deeper reef surveys, confirms depth ranges/preferences

#### 5.2.5.2. Cons:

Spatially limited, temporally limited

#### 5.2.5.3. Utility:

mutton snapper-no, conch-no, yellowfin grouper – yes, assuming data are available

#### 5.2.6. AUV:

Surveys using an autonomous underwater vehicle (AUV) have been conducted along portions of the deep shelf of PR and VI (personal communication, Graciela García-Moliner). Images are being analyzed for benthic composition; video also documents various organisms. Queen conch were documented at 40 m confirming the likelihood of deep water populations or portions of populations.

#### 5.2.6.1. Pros:

Good spatial coverage across PR and VI

#### 5.2.6.2. Cons:

No temporal replication, data not currently analyzed for conch or finfish

#### 5.2.6.3. Utility:

Demonstrates depth ranges (i.e. conch) but data not readily available.

#### 5.2.7. Monitoring Reef Fish Populations In The VI National Park

**Target:** Reef fish, conch, lobster      **Duration:** 1982 to present  
**Coverage:** St. John; Buck Island, STX      **Data:** PIs; VINPS?

#### 5.2.7.1. Description:

Resource monitoring by the park is probably the most temporally comprehensive of all existing or recent programs. Surveys target reef fishes, queen conch, benthic composition (e.g., corals, seagrass communities). Surveys have included intensive short-term monitoring (monthly at 2 sites from 1988-1991), annual surveys at several sites and a number of other specific survey projects. Visual surveys have been conducted in quasi-permanent sites complemented by trap surveys at various intervals. Visual surveys used consistent or calibrated methods to document

all non-cryptic species in all size classes. NPS Inventory and Monitoring Program has now assumed responsibility of the monitoring efforts with monitoring conducted by NPS in collaboration with cooperators (e.g., NOAA NOS/CCMA Biogeography Team/NOAA Coral Reef Conservation Program. Datasets and field log books from J. Randall have been obtained by PI – Jim Beets and comparisons between Randall’s surveys of the 1950-60s are possible.

#### 5.2.7.2. Pros:

good temporal data, spatially good for STJ, includes sites in St. Croix

#### 5.2.7.3. Cons:

only STJ, number still low, only chosen as “best” reef sites

#### 5.2.7.4. Utility:

for both mutton snapper and yellowfin grouper, for conch-yes, assuming data are available

### 5.2.8. Caribbean Reef Fish Surveys (NOAA Ocean Service Biogeography Team)

**Target:** Reef fish and benthos

**Duration:** 2001 to present

**Coverage:** La Parguera, Buck Island, St. Croix; St. John

**Data:** NOS BT; web

#### 5.2.8.1. Description:

Consists of habitat-stratified 20 x 4 m surveys for reef fish and benthic characteristics. In first five years program surveyed almost 2000 sites for fish assemblage structure and associated fine scale habitat utilization patterns. Surveys focused on La Parguera, PR, Buck Island, STX and VINPS St. John. In Virgin Island surveys: 1 STX yellowfin grouper, 29 STJ, 41 STX mutton snapper. In La Parguera, PR 4 mutton snapper; ~900 conch total (not targeted).

#### 5.2.8.2. Pros:

number of samples good, spatial coverage good in VI, uniform methodology

#### 5.2.8.3. Cons:

Only La Parguera in PR, no St. Thomas, short time series

#### 5.2.8.4. Utility:

conch – yes to define habitat utilization and overall population estimates, yellowfin grouper-no, mutton snapper-calculate density to compare to historical estimates, identify size-specific habitats.

### 5.2.9. Monitoring Reef Ecology, Coral Disease and Restoration

**Target:** Reef fish, conch, and lobster

**Duration:** 1997 to present

**Coverage:** Mona and Desecheo Islands, La Parguera, PR

**Data:** SEFSC (PI)

#### 5.2.9.1. Description:

Survey both permanent sites and random locations examining changes in coral reef ecology (e.g., coral disease, bleaching) and responses of reef fish assemblages. Surveys 2-3 times per year, ~70 modified AGRRA transects (30 x 2 m) for reef fish and benthos, point count



surveys, and arc surveys of coral disease. Bank, shelf and shelf edge reefs, mainly adult habitats, does not target typical nursery habitats. Numbers of these species low: 6 yellowfin grouper over 8 year time frame, no mutton snapper.

#### 5.2.9.2. Pros:

number of samples good, spatial coverage good for western PR, uniform methodology linking habitat characteristics with reef fish assemblages

#### 5.2.9.3. Cons:

Only La Parguera, Mona, Desecheo in PR, no VI, medium time series

#### 5.2.9.4. Utility:

conch-no, yellowfin grouper-no, mutton snapper-no.

### 5.2.10. Coral Reef Ecosystem Studies

**Target:** Reef fish, corals, urchins, sedimentation **Duration:** 2001 to present

**Coverage:** La Parguera, Culebra, St. John **Data:** UPRM; NOS web

#### 5.2.10.1. Description:

NOAA NCCOS-grant funded partnership with UPR as lead. Projects are studying causes of reef degradation. Reef fish and benthic composition studied in permanent replicate transects (multiple depth strata) in forereef habitats of 8 different reefs. In 576 transects (25x 4 m<sup>2</sup>) from 2004-5: 2 mutton snapper (25, 30 cm FL), yellowfin grouper: (0).

#### 5.2.10.2. Pros:

repeat surveys over 5-6 yr period, lots of samples

#### 5.2.10.3. Cons:

only forereef habitats, numbers are low

#### 5.2.10.4. Utility:

conch-no, yellowfin grouper-no, mutton snapper-no

### 5.2.11. Population and habitat-use studies of queen conch, St. John

**Target:** Queen conch

**Coverage:** Shallow water bays of St. John

**Duration:** 2005-2006

#### 5.2.11.1. Description:

Tag-and-recapture, habitat use, and sonic racking study of queen conch in 2 bays in St. John. Arrays of hydrophone receivers are set in positions around the bays so that a positive signal on a receiver correlates to time spent in a particular habitat. Long-term data are being analyzed although the third year of the study is 2007. Numbered tags are being used to estimate population size and demographic rates (Jolly-Seber). Concurrent quantification of habitat characteristics are being recorded for correlation with size-specific habitat selections.

#### 5.2.11.2. Pros:

dedicated conch survey, habitat use info, large number of tags.

#### 5.2.11.3. Cons:

spatially limited, only two bays, only STJ, short timeframe, third year of data being collected.

#### 5.2.11.4. Utility:

conch-yes, mapping habitat utilization patterns and habitat-extrapolations for population estimates, independent estimate of mortality rate.

### 5.2.12. REEF and AGRRA surveys

**Target:** Reef fish

**Coverage:** All areas, potentially

**Duration:** 1990 to present

#### 5.2.12.1. Description:

Trained volunteer divers (Novice to expert) submit personally collected data. AGRRA actually funds some expeditions to collect data. Other analyses have looked at frequency of occurrence as metric for abundance. Size estimates also available. Site referenced. 2500 hours for USVI and 800 hours for Puerto Rico; includes BVI sites for platform-based area coverage.

#### 5.2.12.2. Pros:

larger area, large number of samples

#### 5.2.12.3. Cons:

variability in observers, relative abundance

#### 5.2.12.4. Utility:

finfish only-sighting frequency analysis over time possible, depending on data availability.

### 5.2.13. Trap Impacts on Coral Reefs and Associated Habitats

**Target:** Fish and lobster traps      Note: Studying impacts to habitat but also collecting catch composition from traps sampled

**Coverage:** All US Caribbean

**Duration:** 2001 to present

#### 5.2.13.1. Description:

Examines the distribution and density of traps fished, the placement of traps by habitat type, the seasonal changes in distribution of traps among habitats, and the potential for damage by traps to various habitats such as sea grasses, macroalgae, sponges, and hard and soft corals. Species composition of trap catches are analyzed by habitat. Divers survey traps for catch composition and damage to habitat caused by traps.

#### 5.2.13.2. Pros:

large spatial coverage, multi-year, multi-habitat

5.2.13.3. Cons:

traps provide only relative density of fish and fail to sample all sizes of fish, traps are inappropriate for conch sampling

5.2.13.4. Utility:

not useful for conch, may provide habitat specific relative densities of yellowfin grouper and mutton snapper

5.2.14. Shallow water surveys of adjacent habitats

**Target:** Reef fish, conch, and lobster Note: Compares sampling methods and habitat use; mainly juveniles and subadults

**Coverage:** Shallow water bays of St. John

**Duration:** 2001-2003; 2005

5.2.14.1. Description:

Random visual transects and lift net samples in three bays in St. John. Sampled multiple habitats; including seagrass, mangrove, coral rubble, and sandy bottoms. Sampled fall and spring with eight samples in each habitat for 32 total samples per season. Visual transects complemented the lift net sampling effort. A small number of conch (approximately 21 juveniles) observed, but no yellowfin grouper or mutton snapper observed.

5.2.14.2. Pros:

standardized sampling methodology, densities of animals determined

5.2.14.3. Cons:

limited spatial coverage, sampling effort may be inappropriate for larger size classes of yellowfin grouper and mutton snapper

5.2.14.4. Utility:

may be used to help estimate juvenile conch densities in some habitats, not useful for yellowfin grouper or mutton snapper

5.3. Conch Habitat Affinity Analysis To Determine Domain (Island) Wide Estimates Of Conch Abundance

5.3.1.1. General Description:

The SEDAR 14 indices working group recommends that population estimates of queen conch be developed from available fishery independent data. The objective of this analysis is to determine whether the spatial distribution of immature and mature conch is affected by benthic habitats and to determine specific conch habitat preferences, if such preferences are detectable with the available data. Such preferences will then be used to develop domain-wide estimates of conch abundance for the three island jurisdictions governed by the Caribbean Fisheries Management Council.

*Datasets to be analyzed:*

1. NOAA Biogeography's (NOAA BP) conch data from La Parguera, Puerto Rico, St John, and St. Croix.
2. NOAA conch data from Fish Bay, St. John
3. SEAMAP conch data, if such data are available

*Proposed Analytical Methods*

Conch habitat preferences will be explored by analyzing the presence and variation in the abundances of immature and mature conch in different habitats. These habitat affinities (by life stage if possible) will then be used to identify habitats that are not used by conch, as well as those habitats that are utilized or preferred by conch. Conch data by life stage will be overlaid on the NOAA benthic habitat maps in ArcView GIS to determine abundance in different habitats classifications. NOAA benthic maps contain 27 benthic classifications. Appropriate multivariate approaches (e.g., PCA, Factor Analysis, Multivariate analysis of Variance) will be used to determine the fewest number of classifications that significantly ( $P < 0.05$ ) affect the presence/absence ratios and abundances of conch life stages. Appropriate multiple comparison tests will then be used to identify which of the habitat classifications show differences in conch presence/absence ratios and abundances. Domain (island) wide estimates of immature and mature conch abundances will then be developed from proportional-area weighted mean estimates of conch abundance in each habitat classifications. Population estimates of conch abundance will then be provided for use as inputs into production models.

*Some basic criteria to be met by the conch data the analysis described above*

Every habitat classification in the island domain must have been sampled for conch. For example, the above analysis would be invalid if some of the habitat classifications in St. Croix, were never sampled by NOAA BP to determine if conch were present or not. If such a scenario occurs, the benthic classifications would be aggregated upwards until all available habitats have some minimal number of samples on them before the analysis is conducted. At worst, two habitat classifications – hard bottom and soft bottom – could be used because NOAA BP sampling is stratified by those two classifications. This should not be a problem with Ron Hill's data because a complete census that sampled most or all habitats for conch was conducted in Fish Bay.

Conch data sets are large enough to provide the minimum number of samples to adequately describe conch abundances within each benthic classification. Some power or variance analyses would be needed to determine either the minimum number of samples needed to estimate conch abundance within each benthic classification with some predefined level of precision or 2) the power (confidence) associated the conch estimates based on the number of samples available in each benthic classification. Again, NOAA BP sampling was not optimized for conch detection, and such analyses were not done *a priori* with respect to conch.

#### 5.3.1.2. Utility:

The SEDAR 14-DW working group recommends developing queen conch population estimates based upon extrapolations from observed habitat specific conch densities and estimates of total area of conch habitat.

#### 5.4. Research Recommendations:

- 1) Fisheries-independent survey efforts currently rarely include stations in deep water, the preferred habitat of adult mutton snapper and adult yellowfin grouper. In addition, large aggregations of queen conch have been reported in deep water by commercial fishers. The group highly recommends the initiation and continued funding of such surveys. As trends can be regional in nature, the group highly recommends that such surveys be conducted throughout Puerto Rico and the US Virgin Islands.
- 2) The commercial landings data from Puerto Rico and the US Virgin Islands have been incompletely entered and a variety of problems are known to exist in those data. The group strongly recommends that every effort be made to resolve the problems with those data. This should include extensive meetings with port samplers and others familiar with the US Caribbean fisheries.
- 3) The group recommends that tag-recapture studies of mutton snapper, yellowfin grouper, and queen conch be conducted in Puerto Rico and the US Virgin Islands to determine habitat utilization and movement of those species.
- 4) Ongoing long-term monitoring studies should be expanded spatially and include data useful for stock assessment, e.g. size-frequency and density information.
- 5) It is suggested that areas exploited by fishermen be compared to those areas where monitoring has been ongoing to further knowledge of essential habitat for these species and improve the design of monitoring efforts (i.e., ensure that monitoring is reflective of fished conditions).
- 6) The group recommends that efforts be made to monitor spawning aggregations of finfish to improve measures of population abundance. Collection of historical indicators of spawner abundance (e.g., directed visual census, analysis of catch statistics for spawning peaks, etc).
- 7) The group encourages the collection and documentation, for this and future Caribbean assessments, of historical information for qualitative and/or quantitative comparisons of current conditions.

#### 5.5. Literature Cited

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- Valle-Esquivel, M. 2002b. U.S. Caribbean queen conch (*Strombus gigas*) data update with emphasis on the commercial landings statistics. NOAA/NMFS Southeast Fisheries Science Center Sustainable Fisheries Division Contribution No. SFD-01/02-169. pp. 118.

**Table 5-1.** A summary of catch series from Puerto Rico and the US Virgin Islands available for the SEDAR14 data workshop.

Fishery Type	Data Source	Area	Years	Catch Units	Effort Units	Standardization Method	Age Range	USE for BASE
COM Mutton Snapper	PR	Whole island	1983-2005	Pounds	Trip	Nominal series presented	Adults	REVIEW after revisions
COM Yellowfin grouper	PR	Whole island	1983-2005	Pounds	Trip	Nominal series presented	Adults	REVIEW after revisions
COM Conch	PR	Whole island	1983-2005	Pounds	Trip	Lognormal on positive SCUBA, skin diving, spear fishing trips	Adults	NO
COM Conch	PR	Whole island	1983-2005	Pounds	Trip	Delta-lognormal on all SCUBA, skin diving, spear fishing trips	Adults	REVIEW after revisions
COM Conch	PR	SW PR	1983-2005	Pounds	Trip	Lognormal on positive SCUBA, skin diving, spear fishing trips	Adults	NO
COM Conch	PR	SW PR	1983-2005	Pounds	Trip	Delta-lognormal on all SCUBA, skin diving, spear fishing trips	Adults	NO
COM Conch	St. Croix	Whole island	1987-2005	Pounds	Trip	Lognormal on positive trips	Adults	REVIEW after revisions
COM Conch	St. Thomas/ St. John	2: north, south	1987, 1995-2005	Pounds	Trip	Lognormal on positive trips	Adults	NO

**Table 5-2. Pros and Cons for each constructed index and each data set to be used for population estimates as identified by the SEDAR 14-DW.**

***Fishery Dependent Indices***

***Commercial: Puerto Rico*** (Working group recommended revisions and subsequent review of indices of conch and finfish)

- Pros:
- 1) Relatively long time series (1983-2005, recommend using data beginning in 1989)
  - 2) Large sample sizes
  - 3) Includes landings in all areas in Puerto Rico
- Cons:
- 1) Influenced by regulatory changes
  - 2) Difficulty in estimating an informative measure of effort
  - 3) Difficulty in identifying a conch trip
  - 4) Some recognized data problems including: reports of multiple trips per trip ticket, missing data elements, temporal change in data reliability
  - 5) Data time series may not pre-date period of heavy exploitation, if occurring, of these fisheries

***Commercial: US Virgin Islands*** (Working group recommended revisions and subsequent review of conch and finfish)

- Pros:
- 1) Relatively long time series (1987-2005)
  - 2) Relatively large sample sizes of conch in St. Croix
  - 3) Includes landings in all areas in of the US Virgin Islands
  - 4) Data are trip specific
- Cons:
- 1) Influenced by regulatory changes
  - 2) Difficulty in estimating an informative measure of effort
  - 3) Difficulty in identifying a conch trip
  - 4) Some recognized data problems including: missing data elements,
  - 5) Data entry ongoing
  - 6) Data are not species specific for finfish
  - 7) Data time series may not pre-date period of heavy exploitation, if occurring, of these fisheries

***Fishery Independent***

***Conch Habitat Affinity Analysis To Determine Domain (Island) Wide Estimates Of Conch Abundance*** (working group recommends incorporating data from several sources to develop habitat specific abundance estimates)

Data sources to include:

**Caribbean Reef Fish Surveys (NOAA Ocean Service Biogeography Team)**

- Pros:
- 1) large number of samples
  - 2) spatial coverage good in USVI



## 3) uniform methodology

- Cons: 1) only sampled La Parguera in Puerto Rico  
2) no St. Thomas samples  
3) short time series

***Table 5-2.** Pros and Cons for each constructed index and each data set to be used for population estimates as identified by the SEDAR 14-DW, continued.*

**Population and habitat-use studies of queen conch, St. John (NOAA Fisheries SEFSC)**

- Pros: 1) dedicated conch survey  
2) habitat use information  
3) large number of samples
- Cons: 1) spatially limited, only two bays, only STJ  
2) short timeframe, third year of data being collected.

**SEAMAP – Caribbean: Reef Fish Sampling (USVI DFW, PR DNER, NOAA Fisheries)**

- Pros: 1) repeated sampling  
2) uniform method across all locations  
3) sampling deeper than diver surveys  
4) broad range of species  
5) CPUE calculated as minutes of fishing time.
- Cons: 1) interannual variability unknown  
2) overall numbers of yellowfin grouper low  
3) no mutton snapper caught in Virgin Islands sampling  
4) only St. John and St. Croix sampled

**Table 5-3.** Standardized CPUE and coefficients of variation by year for Puerto Rico lognormal (positive trips), delta lognormal, and southwest Puerto Rico lognormal commercial conch fishery indices where trips=1, 0, or missing and the indices where trips=1. Based upon the Valle-Esquivel 2002 models.

Year	PR Lognormal Model				PR Delta Lognormal Model				SW PR Lognormal Model			
	Trips=1, 0, or missing		Trips=1		Trips=1, 0, or missing		Trips=1		Trips=1, 0, or missing		Trips=1	
	Standardized Index	CV	Standardized Index	CV	Standardized Index	CV	Standardized Index	CV	Standardized Index	CV	Standardized Index	CV
1983	1.282722	0.161695	1.099804	0.167158	0.472855	0.383906	0.364786	0.416774	1.493672	0.281423	1.567923	0.245642
1984	2.508396	0.153447	2.434079	0.180734	1.801727	0.332789	1.585428	0.417208	3.070987	0.26103	4.460373	0.282318
1985	1.088235	0.170069	1.050679	0.16931	1.440829	0.3164	1.551966	0.323901	1.444196	0.301989	1.198006	0.23584
1986	1.542049	0.15579	1.697731	0.203917	2.563627	0.262299	1.917167	0.456917	1.910584	0.225756	2.048343	0.266807
1987	1.346603	0.157584	1.03739	0.305655	1.809497	0.287755	0.570267	0.727135	1.301137	0.221555	0.722823	0.379946
1988	1.560645	0.1652	1.640188	0.163937	2.151744	0.288612	2.543118	0.2914	1.5664	0.236788	1.43374	0.173994
1989	1.140635	0.161176	1.223981	0.159457	1.120185	0.320149	1.337631	0.324764	0.593139	0.220396	0.580967	0.159862
1990	0.695147	0.157777	0.63508	0.160638	0.721901	0.314215	0.648881	0.338351	0.561266	0.225545	0.491667	0.163184
1991	0.749652	0.157621	0.716621	0.158009	0.929416	0.296753	0.966622	0.307566	0.524998	0.221647	0.487396	0.165809
1992	0.747949	0.162803	0.75098	0.165327	1.028009	0.294148	1.148681	0.304257	0.702287	0.221927	0.860309	0.166397
1993	0.776497	0.157039	0.807141	0.15606	1.03573	0.289302	1.245904	0.290505	0.873223	0.211985	0.807508	0.153404
1994	0.68958	0.155265	0.706432	0.153856	0.747211	0.305859	0.877519	0.308207	0.737437	0.209947	0.653285	0.149378
1995	0.744887	0.155634	0.768953	0.153894	0.833951	0.303571	0.972865	0.306277	0.730817	0.213712	0.665385	0.153315
1996	0.742986	0.162214	0.775257	0.160511	0.779788	0.316577	0.889434	0.322741	0.599489	0.210391	0.553306	0.148866
1997	0.74287	0.155184	0.77052	0.153497	0.733774	0.313473	0.833421	0.319288	0.662222	0.213197	0.596606	0.151922
1998	0.974463	0.155207	0.964206	0.157481	0.708691	0.336545	0.737794	0.351042	0.772075	0.214123	0.722079	0.156054
1999	0.891705	0.155666	0.908196	0.154115	0.642454	0.340678	0.749846	0.344202	0.965166	0.214043	0.901261	0.153686
2000	0.725493	0.15924	0.762746	0.157963	0.516868	0.342576	0.604965	0.348247	0.764296	0.211794	0.727772	0.150676
2001	0.766742	0.155771	0.802683	0.15397	0.486229	0.345585	0.566074	0.350698	0.731213	0.21163	0.678899	0.150466
2002	0.774117	0.155457	0.80902	0.153664	0.533528	0.34091	0.620155	0.345813	0.743309	0.211374	0.698865	0.150037
2003	0.967044	0.159243	1.020742	0.157355	0.624091	0.350515	0.729741	0.355495	0.768018	0.210585	0.732815	0.149001
2004	0.816224	0.163761	0.854192	0.161989	0.595181	0.347971	0.688838	0.353315	0.708761	0.211261	0.678488	0.149777
2005	0.725359	0.156473	0.76338	0.154633	0.722715	0.316686	0.848897	0.320738	0.775311	0.211632	0.732182	0.149957

**Table 5-4.** Standardized CPUE and coefficients of variation by year for Puerto Rico lognormal (positive trips) and delta lognormal commercial conch fishery indices where trips=1, 0, or missing and the indices where trips=1. Based upon 2007 models.

Year	PR Lognormal Model		PR Delta Lognormal Model	
	Trips=1, 0, or missing	Trips=1	Trips=1, 0, or missing	Trips=1
	Standardized Index			

**Table 5-5.** Standardized CPUE and coefficients of variation by year for southwest Puerto Rico lognormal (positive trips) and delta lognormal commercial conch fishery indices where trips=1, 0, or missing and the indices where trips=1. Based upon 2007 models.

Year	SW PR Lognormal Model				SW PR Delta Lognormal Model			
	Trips=1, 0, or missing		Trips=1		Trips=1, 0, or missing		Trips=1	
	Standardized Index	CV	Standardized Index	CV	Standardized Index	CV	Standardized Index	CV
1983	1.385494	0.272632	1.239216	0.316398	0.212139	0.745186	0.148417	0.820828
1984	2.883343	0.254585	4.143085	0.34211	1.027988	0.599848	1.117671	0.838149
1985	1.341667	0.294138	1.024057	0.310511	1.330679	0.538979	1.035409	0.535551
1986	2.048733	0.217009	2.205534	0.30898	3.190641	0.310297	3.457101	0.529509
1987	1.281536	0.213953	0.718493	0.41265	1.756551	0.34313	1.312088	0.722221
1988	1.648921	0.229789	2.57767	0.275935	1.950217	0.39206	3.732525	0.330373
1989	0.583586	0.212208	0.67097	0.211799	0.685911	0.377829	0.661113	0.372761
1990	0.58085	0.218255	0.473091	0.233902	0.763696	0.356702	0.518179	0.381178
1991	0.533879	0.214203	0.444225	0.254127	0.690214	0.355017	0.567481	0.36505
1992	0.724648	0.214219	0.817199	0.261615	1.298867	0.266932	1.495859	0.309913
1993	0.892167	0.204193	0.866256	0.244737	1.61294	0.250609	1.587273	0.287259
1994	0.773839	0.202313	0.511062	0.2191	1.247194	0.277841	0.758617	0.307652
1995	0.696536	0.205899	0.571294	0.22343	0.737189	0.390322	0.644198	0.368977
1996	0.627168	0.20282	0.522196	0.220015	0.672587	0.380058	0.577961	0.364613
1997	0.692875	0.2052	0.544536	0.222703	0.672912	0.406482	0.516619	0.3973
1998	0.818966	0.204701	0.608645	0.226152	0.468793	0.500542	0.298528	0.506501
1999	1.035642	0.204792	0.879431	0.223368	0.698943	0.475645	0.607881	0.450638
2000	0.804153	0.202769	0.69944	0.215946	0.740849	0.419613	0.558955	0.423137
2001	0.696244	0.202389	0.643116	0.216873	0.607935	0.429313	0.552436	0.413629
2002	0.718684	0.202098	0.674885	0.217455	0.612452	0.433575	0.533645	0.426123
2003	0.759812	0.201434	0.711587	0.218614	0.76566	0.396999	0.760493	0.372452
2004	0.688098	0.202147	0.625713	0.235913	0.582909	0.432944	0.630879	0.393653
2005	0.783158	0.203031	0.828301	0.230882	0.672736	0.427904	0.926669	0.368234

**Table 5-6.** Relative Contribution (% weight) of commercial CPUE samples by Gear and year for yellowfin grouper, all observations where NTRIPS $\geq$ 1 included. N=number of trips.

Year	Cast Net	Dive, Spear, Scuba	Net	Other	Pot	Hook and Line	Seine	Vertical Line	All
	N								